PROCEEDINGS

OF

THE AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.

FIFTH MEETING,

HELD AT CINCINNATI, OHIO, MAY 1851.

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1851.

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Dr. S. G. MORTON.

Sub-Committee, in the name of the Standing Committee, to revise, alter, adopt, and publish the Rules of Organization, presented at the meeting of the Standing Committee, held on Monday, August 26.

Prof. A. D. BACHE.
Prof. S. F. BAIRD.
Prof. JOS. HENRY.

Sub-Committee to report a list of Colleges whose Professors in branches of Science are members of the Association, with the Names of the Professors, and also the Names of those who are not yet Members.

S. F. BAIRD, *Permanent Secretary.*

Sub-Committee to prepare and present to the Association a System of Scientific Ethics.

Prof. JOSEPH HENRY.

* This committee has also been requested to consider the propriety of memorializing Congress on the subject of granting public lands to Missouri, for the purpose of carrying on a geological survey of that State.

Sub-Committee to make Arrangements for Reporting Proceedings of the Albany Meeting.

Prof. D. Olmsted of Yale. | Prof. S. F. Baird, *Permn't Sec'ty.*

The following amendments to the Constitution are to be acted on at the Albany meeting, August, 1851:

1st. That the Permanent Secretary shall erase from the list of members the names of all those who, by the return of the Treasurer, shall appear to be two years in arrears for annual dues;—suitable notice being given by two circulars from the Treasurer, at an interval of three months, to all who may fall within the intent of this provision.

2d. That the annual subscription of each member of the Association be two dollars, which shall entitle him to a copy of the proceedings of each annual meeting.

OBJECTS AND RULES OF THE ASSOCIATION.

OBJECTS.

THE Society shall be called "The American Association for the Advancement of Science." The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of the United States; to give a stronger and more general impulse, and a more systematic direction to scientific research in our country; and to procure for the labors of scientific men, increased facilities and a wider usefulness.

RULES.

MEMBERS.

RULE 1. Those persons whose names have been already enrolled in the published proceedings of the Association, and all those who have been invited to attend the meetings, shall be considered members, on subscribing to these rules.

RULE 2. Members of scientific societies, or learned bodies, having in view any of the objects of this Society, and publishing transactions, shall likewise be considered members, on subscribing to these rules.

RULE 3. Collegiate Professors of Natural History, Physics, Chemistry, Mathematics, and Political Economy, and of the theoretical and applied Sciences generally; also, Civil Engineers and Architects who have been employed in the construction or superintendence of public works, may become members, on subscribing to these rules.

RULE 4. Persons not embraced in the above provisions, may become members of the Association, upon nomination by the Standing Committee, and by a majority of the members present.

OFFICERS.

RULE 5. The officers of the Association shall be a President, Secretary, and a Treasurer, who shall be elected at each Annual Meeting, for the meeting of the ensuing year.

MEETINGS.

RULE 6. The Association shall meet annually, for one week or longer, the time and place of each meeting being determined by a vote of the Association at the previous meeting; and the arrangements for it shall be entrusted to the officers and the Local Committee.

STANDING COMMITTEE.

RULE 7. There shall be a Standing Committee, to consist of the President, Secretary, and Treasurer of the Association, the Officers of the preceding year, the Chairmen and Secretaries of the Sections, after these shall have been organized, and six other members present, who shall have attended any of the previous meetings; to be elected by ballot.

RULE 8. The Committee, whose duty it shall be to manage the general business of the Association, shall sit during the meeting, and at any time in the interval between it and the next meeting, as the interests of the Association may require. It shall also be the duty of this Committee to nominate the General Officers of the Association for the following year, and persons for admission to membership.

SECTIONS.

RULE 9. The Standing Committee shall organize the Society into Sections, permitting the number and scope of these Sections to vary, in conformity to the wishes and the scientific business of the Association.

RULE 10. It shall be the duty of the Standing Committee, if, at any time, two or more Sections, induced by a deficiency of scientific communications, or by other reasons, request to be united into one; or if at any time a single Section, overloaded with business, asks to be subdivided, to effect the change, and generally to re-adjust the subdivisions of the Association, whenever, upon due representation, it promises to expedite the proceedings, and advance the purposes of the meeting.

SECTIONAL COMMITTEES AND OFFICERS.

RULE 11. Each Section shall appoint its own Chairman and Secretary of the Meeting, and it shall likewise have a Standing Committee, of such size as the Section may prefer. The Secretaries of the Sections may appoint assistants, whenever, in the discharge of their duties, it becomes expedient.

RULE 12. It shall be the duty of the Standing Committee of each Section, assisted by the Chairman, to arrange and direct the proceed-

ings in their Section, to ascertain what written and oral communications are offered, and, for the better forwarding the business, to assign the order in which these communications shall appear, and the amount of time which each shall occupy; and it shall be the duty of the Chairman to enforce these decisions of the Committee.

These Sectional Committees shall likewise recommend subjects for systematic investigation, by members willing to undertake the researches, and present their results at the next Annual Meeting.

The Committees shall likewise recommend Reports on particular topics and departments of science, to be drawn up as occasion permits, by competent persons, and presented at subsequent Annual Meetings.

REPORTS OF PROCEEDINGS.

Rule 13. Whenever practicable, the proceedings shall be reported by professional reporters or stenographers, whose reports are to be revised by the Secretaries before they appear in print.

PAPERS AND COMMUNICATIONS.

Rule 14. The author of any paper or communication shall be at liberty to retain his right of property therein, provided he declares such to be his wish before presenting it to the Society.

GENERAL AND EVENING MEETINGS.

Rule 15. At least three evenings of the week shall be reserved for General Meetings of the Association, and the Standing Committee shall appoint these and any other General Meetings which the objects and interests of the Association may call for.

These General Meetings may, when convened for that purpose, give their attention to any topics of science which would otherwise come before the Sections; and thus all the Sections may, for a longer or shorter time, reunite themselves to hear and consider any communications, or transact any business.

It shall be a part of the business of these General Meetings, to receive the Address of the President of the last Annual Meeting, to hear such reports on scientific subjects, as, from their general importance and interest, the Standing Committee shall select; also, to receive from the Chairmen of the Sections, abstracts of the proceedings of their respective Sections, and to listen to communications and lectures explanatory of new and important discoveries and researches in science, and new inventions and processes in the arts.

ORDER OF PROCEEDINGS IN ORGANIZING A MEETING.

RULE 16. The Association shall be organized by the President of the preceding Annual Meeting: the question of the most eligible distribution of the Society into sections shall then occupy the attention of the Association, when a sufficient expression of opinion being procured, the meeting may adjourn, and the Standing Committee shall immediately proceed to divide the Association into Sections, and to allot to the Sections their general places of meeting. The Sections may then organize by electing their officers, and proceed to transact scientific and other business.

LOCAL COMMITTEE.

RULE 17. The Standing Committee shall appoint a Local Committee from among members residing at or near the place of meeting for the ensuing year; and it shall be the duty of the Local Committee, assisted by the officers, to make arrangements for the meeting.

SUBSCRIPTIONS.

RULE 18. The amount of the Annual Subscription of each member of the Association shall be one dollar, which shall entitle him to a copy of the proceedings of each meeting. The Members attending an Annual Meeting shall pay, on registering their names, an additional assessment of ——— dollars. These subscriptions to be received by the Treasurer or Secretary.

ACCOUNTS.

RULE 19. The accounts of the Association shall be audited annually, by Auditors appointed at each meeting.

ALTERATIONS OF THE CONSTITUTION.

RULE 20. No article of this Constitution shall be altered or amended, without the concurrence of three-fourths of the members present, nor unless notice of the proposed amendment or alteration shall have been given at the preceding Annual Meeting.

MEMBERS

OF THE

AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.

NOTE.—Names of deceased members are marked with an asterisk, (*), and those of members who, in 1840, formed the original "Association of American Geologists," are in small capitals.

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Wells, Dr. Thomas, New Haven.
Weld, Henry Thomas, jr., Esq., Mount Savage Works. Md.
Weld, Mason C., New Haven.
West, Charles E. Esq., N. Y.
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Wetherill, Prof. Leander, Rochester, N. Y.
Wetherill, John P., Esq., Philadelphia.
Wetherill, Dr. Chas. M., Phila.
Whelply, W. J. D., Esq., New York City.
Wheatley, Chas. M., Esq., New York.
Wheatland, Dr. Henry, Salem, Mass.
Whipple, Milton D., Esq., Lowell, Mass.
White, E. B., Esq., Charleston, S. C.
Whitridge, Dr. ——? Charleston, S. C.
White, Rev. George, Marietta, Ga.
Whittich, ——? Esq., Pennfield, Ga.
Whittlesey, Charles, Columbus, O.
Whitney, Asa., Esq., Philadelphia.
Whitney, Eli, Esq., New Haven.
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Wilson, Rev. Wm., Cincinnati.
Wilson, Dr. Samuel, Charleston, S. C.
Winchell, Alex., Esq., Eutaw, Ala.
Wing, Matthew, Esq., Albany.
Wing, Dr. Joel, Albany.
Winlock, Prof. James, Shelby College, Ky.
Winslow, Rev. G., Staten Island, N. Y.
Wolf, Dr. Elias, New York.
Woodhull, Lieut. Maxwell, U. S. N.
Woolsey, Prof. Theodore D., New Haven.
Worcester, Dr. Jos. E.. Cambridge, Mass.
Worther, A. H., Esq., Warsaw, Ill.
Woodbury, Hon. L., Portsmouth, N. H.
Wragg, Dr. W., Charleston, S. C.
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Wright, Chas. W., Esq., Cincinnati.
Wurtz, Jacob A. Esq., New York.
Wyman, Dr. Jeffries, Cambridge.
Wyman, Dr. Morrill, Cambridge.

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Yandell, Prof. L. P. Louisville, Ky.
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Yeadon, Richard, Esq., Charleston, S. C.
Young, Prof. Ira, Hanover, N. H.
Young, Wm. L., Esq., Vicksburg, Miss.
Zimmermann, C., Esq., Columbia, S. C.

TABLE OF CONTENTS.

AFTERNOON SESSION.

EVENING SESSION.

Third Day, Wednesday, May 7, 1851.

MORNING SESSION.

AFTERNOON SESSION.

EVENING SESSION.

Fourth Day, Thursday, May, 8th, 1851.

MORNING SESSION.

AFTERNOON SESSION.

Fifth Day, Friday, May 9th, 1851.

Morning Session.

Afternoon Session.

PROCEEDINGS

OF THE

CINCINNATI MEETING, 1851.

FIRST DAY: MONDAY, MAY 5, 1851.

THE first session of the Fifth Meeting of the American Association for the Advancement of Science, was held in the Lecture Room of College Hall, Cincinnati, at 3, P. M. Prof. ALEXANDER DALLAS BACHE, President of the year 1850–51, took the Chair.

The meeting was opened with prayer, by the Rev. SAMUEL W. FISHER, of Cincinnati.

The list of OFFICERS was then read, as follows:

Prof. ALEXANDER DALLAS BACHE, *President.*
Prof. SPENCER F. BAIRD, *Permanent Secretary.*
Prof. WILLIAM B. ROGERS, *General Secretary.*
Dr. ALFRED L. ELWYN, *Treasurer.*

STANDING COMMITTEE.

Prof. A. D. BACHE,
Prof. S. F. BAIRD,
Prof. W. B. ROGERS,
Dr. ALFRED L. ELWYN. } *Ex officio.*

Prof. JOSEPH HENRY,
ED. C. HERRICK, Esq.,

LOCAL COMMITTEE.

Hon. JACOB BURNET, *Chairman,*
THOMAS RAINEY, Esq., *Sec.,*
Prof. O. M. MITCHEL,
Prof. B. SILLIMAN, jr.,
CHARLES STETSON, Esq.,
Hon. TIMOTHY WALKER,
Prof. HORATIO N. ROBINSON,
Rev. Dr. N. L. RICE,
ED. D. MANSFIELD, Esq.
Rt. Rev. Bishop PURCELL,
Dr. JOSEPH RAY,
JOHN P. FOOTE, Esq.,
Dr. J. A. WARDER,
ROBT. BUCHANAN, Esq.
Hon. NATHAN GUILFORD,

The minutes of the Meeting of the Standing Committee, held at the Burnet House, at 11, A. M., were then read, and the several recommendations therein contained, adopted.

The Permanent Secretary was appointed Treasurer, *pro tem.*, in the absence of the regular Treasurer, Dr. Elwyn.

The President read the rules of the Association with regard to the conditions of membership, and remarked upon the necessity of punctuality in attendance upon the different meetings, in order to get through the business of the Association in time. He called the attention of the members to the necessity of condensing communications, as far as practicable, by the omission of all matters not strictly new, or belonging to the progress of science. He referred to the fact that the Association was for the advancement or increase of science, not for its diffusion or promotion. It is only by adhering rigidly to this fundamental principle that the Association can fill the measure of its duty to the science of the day and of this country. As the diffusion, merely, of knowledge, however praiseworthy in itself, is not the object, all matters not new, nor tending to advance science, should be excluded. In this case, only, can the various new subjects brought before the Association be satisfactorily presented and discussed.

The following papers were then presented:

I. On the Law of the Deposit of the Flood-tide. By Lieut. Chas. H. Davis, U. S. N. Superintendent of the Nautical Almanac.

In my memoir upon the Geological action of the Flood-tide, I stated that the deposits which are constantly accumulating upon every alluvial coast are increased, or have their growth, in the direction of the flood stream.

In proof of this, numerous instances were cited of such growth, or accumulation, on the south coast of the State of Massachusetts, and this controlling effect of the flood current was further exemplified by the drift of the materials of wrecked vessels, which was found to be always in the same direction; that is, in the direction of the flood current.

Since the memoir referred to was written, additional instances have been collected, equally well authenticated and important, and all tend-

ing to confirm the conclusion laid down in that paper. In my inquiry into the mechanical action of this law, I have been very much indebted to the able paper of Mr. J. Scott Russell, on Waves, in the Proceedings of the British Association for the Advancement of Science. The details belonging to this subject will be given elsewhere; but it may be said here, generally, that the motion of translation, or motion of the water-particles, in the positive wave of the first order of Mr. Russell's classification, is such as to make that wave "a vehicle for the transmission of mechanical force." This is the form of wave that follows upon the destruction of the waves of the sea upon an alluvial coast. The wave of the sea is of the second order: in passing from the second to the first order, the motion of the particles changes from the motion of oscillation to that of translation. The matter transported by the current of the flood-tide is subjected to this wave-action; the particles of water, and the suspended matter, being projected forward, at the moment of disintegration, with a mechanical power proportioned to the hight of the wave. The substances beneath the breaking wave also receive a shock, tending to force them further up the beach.

It is under the control of this law that the vast material of the tertiary and drift periods, which constitute the flesh and muscles of the great continents, have been saved from wasteful diffusion in the depth of the ocean, and have been grouped around their original sources. It may be assumed to be one of the subordinate fundamental laws of the globe.

After the reading of Lieut. Davis's note, Prof. Bache stated that he had directed the officer engaged in the Hydrography of Charleston harbor in the Coast Survey, (Lieut. Maffitt,) to take up a considerable bulk of water, at different periods of the ebb or flood tide, with the sand mixed in it, so as to determine the relative amount of deposit in equal quantities of water at different periods of the tide. The examination was not completed; but Lieut. Maffitt had reported that the water, during the flood, contained a very much greater amount of sand than during the ebb. The sand of the bar, during the flood-tide, is, in fact, as termed by sailors, "alive;" a fact which confirms, signally, the proposition of Lieut. Davis.

2. On the Azoic System, as developed in the Lake Superior Land District. By J. W. Foster and J. D. Whitney, U. S. Geologists for said District.

The following is an abstract, only, of this paper:

The term *Azoic* (from ά, negative, and ζωη, life,) was first applied by Murchison and de Verneuil, to designate a class of crystalline rocks, which occur around the Gulf of Finland, whose geological position is below the Silurian System. In it, they include not only gneiss and mica slate, but the igneous rocks, such as granite and diorite, by which they are invaded. We adopt the term, but limit its signification, by applying it to a class of rocks supposed to be detrital in their origin, and to have been formed before the dawn of animal or vegetable life. It comprises the most ancient of the strata which form the crust of the earth, and occupies a distinct position in the geological column; being below the Potsdam sandstone. In this district, the rocks consist, for the most part, of gneiss, hornblende, chlorite, talcose, and argillaceous slates; interstratified with beds of quartz, saccharoidal marble, and immense deposits of specular and magnetic oxide of iron.

Most of these rocks appear to be of detrital origin, but to have been greatly transformed by long-continued exposure to heat. They are sub-crystalline, or compact, in their texture, and rarely present unequivocal signs of stratification. They have been subject to the most violent dislocations. In one place, the beds are vertical; in another reversed; and in another, present a series of folded axes. Intermingled with them is a class of rocks whose igneous origin can hardly be doubted, and to whose presence the metamorphism so characteristic of this series is, in a measure, to be ascribed. They consist of various proportions of hornblende and feldspar, forming traps and basalts; or, where magnesia abounds, pass into serpentine rocks. They appear, in some instances, to have been protruded through the pre-existing strata, in the form of dykes or elvans; in others, to have flowed in broad, lava streams over the ancient surface; and in others, to have risen up through some wide-expanding fissure, forming axes of elevation.

The authors next proceeded to show that, on the supposition of the earth having been, originally, in a fluid state, and gradually undergone a diminution of temperature, we ought to look for the production of crystalline substances, differing widely, if not in chemical composition,

at least in general character and aspect, from those of the present day. They did not regard this transformation as due, simply, to the presence of erupted, or plutonic masses, but to gaseous sublimations, intense pressure, and electro-chemical agencies, generated in the vast laboratory of nature.

They next adverted to the researches of chemists, showing that the same materials, when fused, yielded dissimilar products, depending on the rapidity or slowness in cooling, and the degree of pressure to which they had been subjected. They also spoke of the evidence afforded by the scoriæ of furnaces, as tending to confirm these views.

Since the theory of metamorphism has been generally adopted, many of the rocks which were formerly regarded as igneous, are now referred to aqueous agency, and their transformations traced to the presence of erupted rocks. They here cited numerous examples of metamorphism, showing that argillaceous schist is transformed into gneiss; sandstone into compact vitreous quartz; and limestone into saccharoidal marble, when brought in contact with eruptive masses. They therefore inferred, that these obscurely-bedded rocks,—such as gneiss, and the crystalline schists,—were of sedimentary origin: that no rock was to be regarded as igneous, unless it occur in vast, irregular masses, like granite; in dome-shaped, or crater-like summits, as basalt, or trachyte; in long lines, like dykes or elvans, cutting through the incumbent strata; in ramifying veins, like granite; or broad lava sheets, like trap.

Many eminent geologists maintain, that the lowest stratified rocks are but portions of the Silurian System, and that, from long-continued exposure to heat, the lines of stratification have become obscure, and all traces of organic remains obliterated. Our observations in this district (they remarked) have led us to a different conclusion. If the Potsdam sandstone rest at the base of the Palæozoic Series; if from that epoch we are to date the dawn of organized existence, there is, in this district, a class of rocks, detrital in origin, interposed between the lower Silurian System and the granite; rocks distinct in character, unconformable in dip, and destitute of organic remains. If we found these crystalline schists, and beds of quartz, and saccharoidal marble, graduating into clay-slates, sandstones and limestones, as we receded from the lines of igneous outburst, and enveloping the remains of plants and animals, we would be led to a different conclusion; but so far from it, the evidence is ample that the base of the Silurian System reposes upon their upturned edges, and that the causes by which the

metamorphism of the former was effected had ceased to operate before the deposition of the latter. Between the two systems there is a clear and well-defined line of demarkation. It forms one of those great epochs in the history of the earth, where the geologist can pause, and satisfy himself of the correctness of his conclusions. On the one hand he sees evidence of intense and long-continued igneous agency, and, on the other, of comparative tranquillity and repose.

Having taken a general view of the origin of the azoic rocks, they next proceeded to describe their geographical distribution. They occupy an almost continuous belt along the northern shore of Lake Superior,—subject, however, to occasional interruptions,—and had thence been traced, by Logan and Bayfield, to the coast of Labrador, forming the axis between Hudson's Bay and the Valley of the St. Lawrence.

They are also extensively developed on the southern shore, forming the water shed between the respective river-systems of Lake Superior, Lake Michigan, and the Mississippi. [Mr. Foster here traced their range and extent, on a large map, which will soon be published by order of the government, so that we deem it unnecessary to offer a diagram.] Wherever the junction between the Azoic and Silurian Systems has been observed, the one is found to repose, unconformably, on the other. A section, taken near Carp river, Lake Superior, was exhibited, showing that, while the quartz of the Azoic System occurred in beds, nearly vertical, and afforded ripple-marked surfaces, the Potsdam sandstone of the Silurian epoch was deposited around it in nearly horizontal beds, and, in many instances, filled the ancient fissures of the quartz. Other sections, illustrating the same phenomena, in different parts of the district, were exhibited.

They next proceeded to describe the associated metals. The Azoic Series was characterized by immense deposits of specular and magnetic oxide of iron. This might, with great propriety, be denominated the IRON AGE of Geology; while the Silurian epoch, with equal propriety, might be designated as the COPPER AGE. As a striking example of the magnitude of these deposits, they stated, that near Teal Lake, an iron mountain rose up, in the form of a dome, to the height of 1,067 feet above Lake Superior, and 200 feet above the surrounding country; forming the culminating point, along that line, between Lake Superior and Lake Michigan. It did not consist of pure iron ore, but of alternating bands of a few lines, only, in thickness, of blood-red jasper, and dark, or steel-gray, iron ore, curiously contorted and plicated. Portions of the mass, however, were absolutely pure. Other examples

were cited, where the iron occurred on a scale of nearly equal magnitude. So far as related to the range, extent, and purity of these ores, this district stood unrivaled throughout the world; and the time was not distant when the Great West would look to this source for the finer varieties of bar iron, and cast steel.

From the detailed explorations of Mr. Ch. F. Mersch, communicated to them, and which they purposed soon to publish, there could be no doubt that the Missouri iron region belonged to the same system of upheaval, and occupied the same relation to the Silurian System. They also stated that the magnetic ores of Sweden, associated with gneiss, belonged to the same epoch. The same was true with regard to the ores of the Champlain region of New York; that, although they had been described, by Dr. Emmons, as occurring in purely igneous rocks, they had satisfied themselves, from personal observation over a portion of the district, that this was not the case.

As to the thickness of the Azoic System, it was impossible to form a correct idea. It might be 20,000, or 50,000, or 100,000 feet. If we were to adopt the usual method of measuring across the basset edges of the strata, it would give us a thickness greater than that of the whole fossiliferous series, from the base of the Silurian to the crowning member of the Tertiary. It was evident that these strata were every where plicated and folded, and that the observer passed over a repetition of beds, instead of a succession of beds; but that the strata, throughout the whole region, had been so shattered by earthquakes, and so metamorphosed, by direct or transmitted heat, that it was impossible to identify them, except over limited areas.

Prof. Agassiz remarked, that he had, at the Cambridge meeting of the Association, urged the importance of a close examination of the older rocks of the Palæozoic Series, with a view of arriving at a standard for determining the order of succession of the contained fossils. It had long been an unsettled question with European geologists, whether we could accurately fix upon the exact point, in the palæozoic rocks, in which animal life had commenced. Mr. Lyell was of opinion that we could not. Yet it is now established, by the labors of Messrs. Foster and Whitney, that we can accurately determine this point, and feel certain that we have ascertained the exact strata which contained the fossil remains of the first created animals. If the zoologist would view with interest the skull of the first created man, it is with equal interest that we see, in the Potsdam sandstones, the evidences of the first created animals.

3. ON THE LIMITS OF THE CLASS OF POLYPI, AND THE RANK AND SUCCESSION OF THEIR CHIEF NATURAL DIVISIONS. By Prof. L. AGASSIZ.

[*Not received.*]

4. ON THE ORBITAL COURSES OF STORMS, AS OPPOSED TO THE RECEIVED HYPOTHESES OF GENERAL WINDS, FOUNDED ON THE ALLEGED INFLUENCE OF EQUATORIAL TEMPERATURE. By W. C. REDFIELD, Esq.

[*Not received.*]

Captain WILKES remarked, that, in the Pacific, the orbital motion of some storms which he had examined was in a curve, turned to the east, in south latitude, say from 14° to 32°; and, in reply to a question from Mr. Redfield, stated, that he considered this fact to be the result of a sufficient number of observations.

5. ON THE HOLOTHURIÆ OF THE ATLANTIC COAST OF THE UNITED STATES. By L. F. POURTALÈS.

AT the meeting of the "Association of American Geologists and Naturalists," held at Boston, in 1847, I read a paper *on the Holothuriæ of New England*, which I subsequently considered as too imperfect to be sent in for publication, until I should have collected more information on that subject. At the request of Prof. AGASSIZ, I took up this subject again, in the little time I could save from my regular occupations. I had, in the mean time, obtained specimens of a few species of this family from other parts of the coast, which I now include in this enumeration.

The family of Holothuriæ, although so interesting to the zoologist, on account of its analogies with the annelids among Articulata, can be said to be yet in a state of great confusion; perhaps more so than any other family in the animal kingdom. Almost every naturalist who has been engaged in this study has attempted to classify them; many, however, have only increased the confusion by the creation of new genera, based on insufficient grounds. Perfect specimens are very scarce in collections, owing to the habit these animals have of ejecting their intestines, tentacles, and, in short, all their organs, except skin and muscles, when handled alive. Those organs, therefore, have almost never been used by zoologists for generic characters. The latter have been usually derived either from the general form of the body,—

as, for instance, by de Blainville,—or from the disposition of the suckers, the so-called feet, or from their absence or presence only, as did Brandt. The tentacles have seldom been used, although they would, probably, afford very good characters; but they are seldom found perfect in the specimens preserved in collections. Other characters, subjected to the same difficulty of preserving, could be derived from the hard parts of the skins. In the Echini and Asteriæ, the whole body is covered with hard, calcareous plates, extensively used as means of classifying the species. Many have, also, a complicated system of jaws and teeth. In Holothuriæ, nothing remains except a ring of calcareous pieces around the œsophagus, and in some genera, a smaller ring is seen surrounding the anus, besides numerous very small, calcareous pieces, distributed in the skin and tentacles, all of which present very characteristic forms, when examined under the microscope. A careful, comparative study of them, is a desideratum, in order to get a true knowledge of these animals; and, after having been compared in all the types, afford the best, and, perhaps, the only means of distinguishing the species, and even the genera. As they are, also, the only parts of the Holothuriæ which can be preserved in a fossil state, they will enable us to compare the Holothuriæ of former epochs with the living ones. Indeed, these calcareous pieces have already been noticed, and mistaken for fossil infusoria. As far as I know, the naturalists who have paid most attention to the structure of those cutaneous bodies in Holothuriæ are Düben and Koren, in their work on Scandinavian Echinodermata. The calcareous pieces, surrounding the œsophagus, have often been called the dental ring, or even the teeth; having, at first sight, a resemblance to the maxillæ of Echini. But as they can not be used for mastication,—being scarcely moveable upon each other, and no where reaching the central cavity of the mouth,—this appellation is improper. As their use is only to give a solid point of attachment to the muscles of the tentacles and of the œsophagus, they can, with better reasons, be compared to the projecting auricles of the Echini and Asteriæ, which, in the first, are the supports of the maxillæ, and, in the second, the point of attachment of the muscles distending the mouth and the œsophagus.

I shall now proceed to give a short account of all the representatives of this family found on the Atlantic coast of the United States. It will be seen, that most of them have already been noticed by Dr. A. A. Gould, in his "Report on the Invertebrata of Massachusetts."

Genus ANAPERUS—*Trosch.*

This genus was established by Troschel for those Holothuriæ having the suckers scattered over the whole body; ten tentacles branching off, of which two or three are much smaller than the others; the anus surrounded by calcareous papillæ, a large retractor muscle, and a muscular stomach. How far this genus will hold good, I am unable to tell. It seems to include the genus Thyone, of Oken, for at least the *Th. papillosa,* as described by E. Forbes, answers to the above generic diagnosis. Troschel describes one species from our coast.

1. *Anaperus Carolinus,* Trosch. (in Wiegmann's Archives, 1846.)—It is two or three inches long, of a grayish color, covered with suckers, which are more abundant on the ventral side. The anterior and posterior extremities are usually turned a little upwards. The calcareous ring, surrounding the œsophagus, is very large and strong. There is, also, a smaller calcareous ring, composed of several pieces around the anus. The skin contains few calcareous parts, but each sucker has a small, perforated disk at the end, and sometimes a few elongated calcareous pieces in its stem. The tentacles are large, and ten in number; of a fine purple color, when alive. Two of them are much smaller than the others, and placed side by side at the ventral part of the animal. The tentacles are filled with calcareous parts, which give to them a certain stiffness. When retracted, they are folded up in the mouth, with their extremities directed inside. The stomach is muscular, and contains, sometimes, sand, and small shells. The other internal parts consist in large sexual organs, and the double respiratory tree also of large size. The specimens of this species which I have seen were picked up by Professor Agassiz and myself on the beach at Sullivan's Island, (S. C.,) where they occurred, sometimes, in great abundance. I have also found them on the southern side of Cape Hatteras. They probably inhabit deep water, and are thrown up by the waves; for all the specimens found on the beaches are rolled up to high water mark, where they ultimately perish, and dry up.

2. *Anaperus bryareus,* (Holothuria bryareus, Les.)—Of this species I have had no specimen on hand, and know it only through Lesueur's description, which indicates an Anaperus, in the supposition that the author overlooked the two small tentacles; the number eight being not normal among Holothuriæ. This traveller obtained his specimens from the coast of East Florida, and, according to Say, it is

frequently met with on the shores of New Jersey. Whether Dr. A. A. Gould had exactly the same species before him when writing his Report, I am unable to say.

Genus Colochirus—*Trosch.*

This genus presents the same peculiarities as the preceding one, and only differs from it in having the suckers arranged in five longitudinal rows, of which the three inferior ones are more abundantly furnished with them than the two superior, where only a few are observed.

3. *Colochirus gemmatus*, (Pourt.)—Two specimens of this species were found with *A. carolinus* on Sullivan's Island, (S. C.) One of them is about two and a half inches in length, resembling the latter in color; the other is a little more than half that size, of a dirty white body, and green ambulacra. The internal organs are almost identical with those in Anaperus, as are, also, the tentacles, with the exception that they are proportionally smaller. The skin is studded with microscopical hard bodies—transparent, and refracting the light very strongly. Each one seems to be composed of several rounded pieces, combined so as to leave a hole in their middle. Those rings are again combined together, so as to form flat bodies, with two, three, or more holes in them. The suckers are arranged in five rows, of which three seem to be more abundantly furnished. In this, as well as in the preceding genus, there is a small, calcareous body, occupying a position between two of the posterior projections of the pieces of the calcareous œsophageal apparatus, near the dorsal surface. It has been noticed by Goodsir, in several species of Holothuriæ, and he regards it as a madreporiform tubercle, or nucleus. It is, without doubt, a representative of the madreporic plate of Echini and Asteriæ. It is connected with the sexual canal, which opens on the outside, between the two superior tentacles. This calcareous body has a spheroidal form, and is composed of two pieces, united by a meandriform border.

Genus Cuvieria—*Péron.*

Characterized by having the body covered with hard scales, and tthree rows of suckers on the ventral disk. Only one species is known to inhabit our coast. It was referred, by Dr. A. A. Gould, to *Cuvieria squamata.* Several specimens have been found in the stomachs of fishes. Some of them have also been dredged, alive, among *Laminaria,* in Boston harbor, by Mr. William Stimpson. But as I have seen only dried specimens, of the New England species, and possessing none

of the European, I am unable to give any opinion with regard to their identity.

Unable, at present, to decide as to what genus the following species belong, I prefer calling it Holothuria, rather than to refer it, with doubt, to any other of this group.

4. (*Holothuria*) *Floridana*, (Pourt.)—Body cylindrical, elongated, covered with suckers; which are, however, more abundant, and longer on the ventral surface. Tentacles short, equal, twenty in number; their branches also short, and crowded together in the form of a disk. No hard papillæ around the anus. No muscular stomach. Color, of a dark brown—almost black; tentacles and suckers lighter colored. Size, when alive, from six inches to one foot long, and two or three inches thick. Inhabits muddy flats, formed by the detritus of corals, among the Florida Keys.

Although the suckers are disseminated all over the body, a close inspection will show that they are more abundant in certain regions, which can be considered as the ambulacra. There are three such longitudinal rows, or ambulacra, on the ventral surface, and two on the back; and, consequently, three interambulacral spaces on the dorsal surface, and two on the belly. The dorsal interambulacral spaces are provided, each, with two rows of conical papillæ, one row on each side, close to the ambulacral space: thus making six rows of papillæ, which are more conspicuous in young specimens, three or four inches long, than in the old ones. The two rows, situated nearer to the ventral surface, are always very conspicuous. They are erectile, like the suckers, and possess a canal, which communicates with an internal vesicle.

The skin contains small, calcareous bodies, of various forms, but mostly in that of an irregular cross, or star, the branches of which are bifurcated at their extremity. The suckers are terminated by a calcareous, perforated disk, as in most of the echinoderms. The conical papillæ contain, near their extremity, a bundle of calcareous bodies, in form of a slightly curved rib, with a small, perforated expansion at each end; a form frequently met with in the skin and tentacles of Holothuriæ. The intestinal canal is large, and always filled with calcareous sand, and small shells, which the animal is constantly seen carrying to the mouth, by means of the tentacles, and swallowing.

The ovaries occupy a large space of the cavity of the body: they are filiform, of a pink color, and filled with eggs, in various stages of development. The oviduct opens near the mouth, and has attached to

it, at the place where it meets the circular canal of the Polian vesicle, two clusters of small, white bodies, consisting of an elongated head, supported by a twisted peduncle, both filled with a calcareous network. There are eight or ten such bodies to each cluster.

The Polian vesicle is simple, and elongated, and communicates with a circular vessel, attached to the œsophagus, from which five branches go to the twenty internal vesicles belonging to the tentacles. These vesicles are long, and pointed. The respiratory tree is double: one of its branches is attached to the wall of the cavity on the right side, and terminates near the mouth; the other is free, and is intertwined with the brown vessels accompanying the intestinal canal—probably a liver. The calcareous ring, surrounding the œsophagus, is rather slender, and much shorter, than in *Anaperus Carolinus*.

I have never seen the young ones in the same localities with the adults; having found them only about the Mangrove islands, hidden under old logs lying in the water. They are of a lighter color than the old individuals.

Genus CHIRODOTA—*Eschsch.*

This genus is characterized by the want of feet, and the presence of small tentacles, fifteen in number—at least in those specimens I have examined. Dr. A. A. Gould has described one species, under the name of

5. *Chirodota arenata,* (Gould,) of which I have found several specimens, after storms, on Chelsea beach, near Boston. The tentacles I found to be fifteen in number; small, soft, and divided into five lobes. The calcareous ring is composed of five bifid plates. The calcareous parts of the skin are in the shape of plates, with hexagonal holes. The ovaries, and respiratory branched tubes, are of large size. The madreporic plate is also found in the same position as in Anaperus and Colochirus. The stomach is also muscular, as in those two genera; though, apparently, not so strongly.

I would (provisionally) place in this genus a Holothuria of which I have never seen any perfect specimen. They were all taken from the stomachs of fish, and deprived of all their internal organs. I would propose calling it

6. *Chirodota oolitica,* (Pourt.)—Dr. A. A. Gould* mentions this spe

* Report on the Invertebrata of Massachusetts. 1841: p. 345.

cies, under the head of *Holothuria pentactes;* remarking, at the same time, that it was not determined with certainty. I never could discover any trace of suckers. The specimens which I have got from the stomachs of fishes are about five or six inches long, and very much contracted. The five longitudinal muscles are marked, on the outside, by furrows. The mouth is surrounded by fifteen small, short, soft, and simple tentacles. The calcareous œsophageal ring is almost entirely gone with the intestine. The skin is studded with an enormous quantity of small, rounded, ovate, calcareous bodies, of a reddish brown color, when seen under the microscope. On dissolving in acids, they show a concentric structure. The skin is filled with them to a considerable depth, and acquires from them a brownish purple color. At about a quarter of an inch from the mouth, their number diminishes, so that the tentacles, and a small surrounding area, are deprived of them, and have a white color, in specimens preserved in alcohol.

Genus SYNAPTA—*Eschsch.*

The genus Synapta differs from the typical Holothuriæ, by the fact that the quinary arrangement, which is always constant, and very evident in the latter, is somewhat lost in Synapta. This arrangement is still preserved in the number of the longitudinal muscles. But the tentacles are twelve in number, as also the pieces composing the œesophageal ring. The respiratory tree is completely wanting. It is one of the so-called *aberrant types* of Milne-Edwards, and one of the *degraded* ones of Quatrefages.

This genus has a representative, very common on the sandy and muddy shores of Massachusetts, where it lives buried in the ground, between high and low water mark.

7. *Synapta Girardii,* (Pourt.)—It bears a strong resemblance to the European species *S. inhærens* and *S. Duvernea.* The only difference I can find between it and the latter, is in the shape of the little, microscopic, anchor-like hooks, found within the skin. They are less curved than those of *S. inhærens,* figured by Messrs. Düben and Koren, and the perforated plates on which they are supported are more rounded. From *S. Duvernea* it differs in having, also, the hooks less curved, and besides, in being provided with shorter tentacles. Lately, I discovered two other species of the same genus, at Cape Florida, and which appear to be new to science.

8. *Synapta viridis,* (Pourt.)—Body elongated, the size of a quill,

three or four inches long; of a dark green color, with whitish spots; tentacles lighter, twelve in number, elongated, feather-shaped, and possessing about ten branches on each side, occupying nearly the terminal half of the tentacle. At the base of each tentacle, and toward the mouth, there are two dark specks, composed of a black pigmentum, (eyes?) The skin, when examined under the microscope, exhibits perforated plates, and anchor-shaped bodies, similar to those of the northern species: the only difference is, that they appear larger. Found among bunches of sea-weeds, in Biscayne Bay, Florida.

9. *Synapta rotifera,* (Pourt.)—Same bulk as preceding; body, however, shorter. Twelve short, thick, palmated tentacles, divided into eight or ten branches, of which the middle ones are the longest. Skin transparent, of a light purplish color, covered with white, wart-like spots. Tentacles whitish, with similar spots on their base. The five longitudinal muscles are seen as purple bands. A very young specimen has only four branches to its tentacles, and has white warts arranged regularly, in longitudinal rows, alternating with the muscles. The skin contains, in the white warts, great accumulations of calcareous bodies, in the form of very regular wheels, each having six spokes; a beautiful object under the microscope. Each wart contains about eighty or one hundred of them, of all sizes; the largest having a diameter of about $\frac{1}{3000}$ of an inch. The skin also contains small calcareous, elongated bodies, in the form of those we have observed in the conical papillæ of *H. Floridana.* This species lives in the interstices of the branches of a coral, which occurs on shoals in Biscayne Bay, Florida. I have kept alive this species, and the preceding one, in a glass jar, along the sides of which they would climb, actively, by means of the tentacles; the body hanging down in the water. The *S. viridis* seemed to be the most active, owing to its longer tentacles. They seemed to adhere to the glass by the outside surface of the tentacle and its branches.

It will thus be seen, that, of the Holothuriæ of the Atlantic coast of the United States, we know only eleven species, whilst, in England, Ed. Forbes enumerates fifteen of them. A similar disproportion exists among Echini and Asteriæ. A table given by Forbes, representing the distribution of Echinodermata, may explain this fact. Of the British Holothuriæ one species, only, is littoral; five are from the laminarian region, and nine from the coralline region. Here we only know the littoral species, and those accidentally thrown up by storms. The laminarian and coralline regions, or rocky bottom, are almost a

terra incognita. They would yield a rich crop to the naturalist who would investigate them by means of the dredge, or, perhaps, with better advantage with the drag, an instrument figured in Forbes' "History of British Starfishes."

Two species more are described by Troschel* as inhabiting Labrador;—*Anaperus cigaro* and *Orcula Barthii,* which I mention, here, as belonging to the American fauna.

6. Notice of two Ancient Human Skulls, and other Bones, found in a Cave near Elyria, Lorain Co., Ohio. By Charles Whittlesey, Jr.

Mr. Whittlesey produced the crania, the cavity of the brain in both entire, showing all the developments. He remarked that it was evident that both of them belonged to persons of very low intellectual force, having low, narrow, and shallow foreheads; and that the animal propensities were largely developed. Prof. Agassiz, who saw them a moment, thinks they belong to the present race of Indians. What renders them worthy of notice, is the fact that they are unquestionably ancient; and if skulls of Indians, it will be proven that that race has long been the occupant of this region.

If they are not Indian crania, and belong to another race, it becomes interesting to decide to what race, and thus, whether they belong to the "Mound builders." They are presented for consideration on these grounds.

The position of the skulls was such as to give them a probable age of 2,000 years.

The rock which causes the Falls of Black River, at Elyria, is the "grindstone grit" of the Ohio Reports, whose true geological position is not yet fixed. It is an imperishable coarse-grained sandstone, without pebbles; and the only fossil yet recognized is a fish with a heterocercal tail, not yet classified. Its equivalent in the New York system is not determined, but is referred generally to the Chemung and Portage group. It is about 200 feet below the conglomerate of the coal, usually about 40 feet thick, but here it thickens downward, displacing some of the subordinate beds, so that it appears to rest on what are now considered the Hamilton shales of New York, or the "black slate" of the Ohio Reports. The lower face of the grit is here

* Wiegmann's Archiv., 1846, I. pp. 63 and 64.

about 30 feet above the bed of Black River, and the river is supposed to be 60 feet above the lake, making 90 feet—the surface of the rock being about 140 feet above the lake.

On account of the hard and imperishable nature of the grit, it resists the wearing action of the elements; and the black, or, in some places, the red shale beneath it, being soft, there are in consequence numerous caves and sheltered places, where the sand rock projects far over the base. It was in one of these places that the skulls lay, covered by *four feet* of the accumulated bones and earthy remains of wolves, bears, deer, rabbits, squirrels, fishes, reptiles, snakes, birds, and other creatures not yet determined. Every shovel full thrown out contained more or less of the bones, teeth, jaws, scales, etc., of animals, until finally, at the bottom, resting on clean yellow sand, the parts of *three* human skeletons were found lying in confusion, as though they had perished or been placed there violently, and not by a process of burial.

Although the place was perfectly sheltered from the weather, and dry, the bones were so much decayed, and were so porous, that they would scarcely bear their own weight; and it was only after they had been carefully dried, and then saturated with glue, by Prof. Brainerd, that he could put the fragments of the skull in place as they are now seen. One is evidently that of a female, of under size, and very old. The other, of a male below the age of majority, which has better mental developments than the female. Of the third skeleton, only some ribs and a few other fragments were found.

It appeared as though they had been killed by the falling of some loose rocks from the roof, while they lay asleep in the cave. A stone of 50 or 60 pounds weight lay on the head of one of them, and a still larger piece on the breast of the other.

The substance which had accumulated above them was principally the dirt and earthy powder of animal remains, and their bones, with which were occasional remnants of fires and burnt stones.

Indian arrows of flint were found from top to bottom. The skulls lay at the remotest part of the cave, and were left there before it was occupied by men. It is probable that the human remains were at first covered by the remnants brought by animals into the place, and that it was used also for shelter, and a place for cooking, by whoever inhabited the country previous to the whites. The extent of sheltered space filled with bones, is about 15 feet by 50; and as very little vegetable matter was found in it, the accumulation must have been due principally to the residue of animals, and consequently must have

formed very slowly. This residue has a light, ashy consistency, like guano, and a fat, greasy feel.

A communication was then presented from a Committee of the Ohio Mechanics' Institute, offering to the Association the use of their Hall on and after 9 A. M. of to-morrow. The offer was accepted, and the meeting adjourned to meet in the Hall of the Ohio Mechanics' Institute at 9 A. M., of Tuesday, May 6.

SECOND DAY: TUESDAY, MAY 6, 1851.

(Morning Session.)

The association met in the Hall of the Ohio Mechanics' Institute, at 9 A. M.

The following gentlemen were elected members of the Standing Committee, under the rules; Prof. B. Peirce, Prof. L. Agassiz, Prof. O. M. Mitchel, Capt. Charles Wilkes, U. S. N., Wm. C. Redfield, Esq., and Jos. G. Anthony, Esq.

A letter from Mr. L. Grosvenor, in relation to the geological survey of Illinois was read, stating that an appropriation of $3000 had been made for this purpose, by the Legislature.

The committee on Prof. Mitchel's method of recording astronomical R. A. and N. P. distances, was increased by the addition of Capt. Chas. Wilkes, S. C. Walker, Esq., and Prof. J. H. C. Coffin.

The assessment on members for the meeting, was fixed at three dollars.

Prof. Mitchel was then called to the Chair, and the following papers presented:

1. On the Constitution of Saturn's Ring. By Prof. B. Peirce, of Harvard University.

A memoir upon this subject, by Mr. George P. Bond, was read to the American Academy of Arts and Sciences, upon the 15th April,

and was the occasion of the present investigation. Since Mr. Bond's paper is still unpublished, I shall be obliged to make constant reference to it, and even recapitulate some parts of it, in order that the proper relation of the two paths of research may be correctly understood.

1. The author of the Mecanique Celeste, proved that Saturn's Ring, regarded as solid, would not be sustained about the primary, unless it had decided irregularities in its structure. But the observations of Herschel and others have failed to detect any indication of such irregularity, and a laborious series of observations has finally convinced Mr. Bond of the utter improbability of any important irregularities, and he has, therefore, adopted the conclusion that *Saturn's Ring is not solid but fluid.* Mr. Bond's argument is chiefly derived from observation; whereas a new investigation of the mechanical conditions of the problem has led me one step further. I am now convinced that *there is no conceivable form of irregularity and no combination of irregularities, consistent with an actual ring, which would permit the ring to be permanently maintained by the primary if it were solid.* Hence it follows, independently of observation, that Saturn's Ring is not solid. And now it is worthy of remark that if we adopt, as the basis of calculation, the mass of the ring which was determined by Bessel, the thickness from Bond, and the other dimensions from Struve, we shall find the density to be about one-fourth more than water. So that the ring consists of a stream, or of streams of a fluid rather denser than water, flowing around the primary.

2. Mr. Bond next undertook a series of very ingenious and novel computations, in order to determine from theoretical considerations alone, whether the ring was one or many, and arrived at the remarkable result that *neither of these hypotheses was tenable.* He is, therefore, disposed to reconcile the discrepancies of observation in this respect, by supposing the constitution of the ring to be variable; and that, although the principal division, which has been always observed, is permanent, *the other divisions are constantly annihilated by the mutual concussion of the rings, and again reproduced by some process which he does not undertake to define.* This bold theory is fully sustained by my own analytical investigations, and not only do my researches exhibit the possibility of this strange phenomenon, but they even show the precise mode of action, and how it must be in the case of nature. If the ring had been originally one, it would soon have subdivided itself at definite points, which can be exactly computed, into portions of a determinate width. The disturbing causes must, however, drive

these separate rings, sooner or later, against each other. There must then follow an interchange and crossing of currents, a mutual retardation, a momentary state of equilibrium, as one ring, and then another, breaking up, when the same process would be repeated in endless succession.

3. But even a fluid ring would not be permanently retained by the direct action of the primary. For whatever may be its figure, the velocity of its currents must be slower at the points which are more remote from the planet; so that there must be an accumulation of fluid at these points. An exact analysis shows that the accumulation precisely balances the greater distance, and hence the ring is attracted equally in every direction. The regulating action upon the motion of the center of gravity is, therefore, cancelled; and it must continue to move uniformly in any direction in which it may have been started by a foreign influence. It must move on until it is destroyed by striking the surface of the planet. How has Saturn's Ring escaped this catastrophe? Simply because the disturbing forces have counteracted their own effects. The satellites are constantly disturbing the ring; but, in the very act of perturbation, they are sustaining it in its place. Their sustaining action is not negative, but positive; and without satellites there could be no ring. The theory of this curiously sustaining power may be variously illustrated. In the first place, each particle of the ring may be regarded as a satellite, which the other satellites disturb in the usual way. Thus the mean distance from Saturn is not varied in the least, and the disturbance of the eccentricity can only reach certain definite limits, after attaining which it must diminish. Secondly, in consequence of the attraction of its satellites, Saturn describes an orbit about the common center of gravity of the system; each particle of the planet tends to move in this same orbit. The center of gravity of the ring, must, likewise, tend to describe nearly this same orbit, and its orbit would be precisely the same, if the attraction of the ring for the satellites were the same as if its mass were accumulated at its center of gravity. But the deviation may be safely neglected, and referred to the class of periodical perturbations.

4. It follows, then, that no planet can have a ring, unless it is surrounded by a sufficient number of properly arranged satellites. Saturn seems to be the only planet which is in this category, and it is the only one, therefore, which could sustain a ring. Our Sun, also, does not appear to have its satellites properly disposed for supporting a ring; and the only part of the system where such a phenomenon might have

been reasonably expected, is just within the powerful mass of Jupiter. But had there been a ring at this part of the system, it must have been subject to such extraordinary perturbations, that it would, in the course of time, have been vibrated up against the next interior planet, Mars: and, in this way, have been broken into asteroids. The orbits of planets formed under such circumstances, would have been naturally characterized by great eccentricity.

5. But suppose that, from any cause whatever, the Sun had, at some period, been surrounded by a light ring comparable in levity to the zodiacal light; and in order to escape the planetary influences, we may suppose the plane of the ring to have had a large inclination to the ecliptic. The result would have been that the center of gravity of the ring would have soon begun to move in some direction or other, and have continued moving until it was brought against the surface of the Sun. But during this motion, and in consequence of the solar action, the matter of the ring would have accumulated at the most remote part; so that if the Sun were a mere point, it would have happened that, at the very instant of its expected meeting with the ring, the whole ring would have escaped from the point of contact. The experiment of Tantalus would have been performed on a grand scale, and the ring would have been instantaneously transformed into a comet in its aphelion.

6. If, however, the ring were supposed to be a large gaseous mass of a circular figure, the condensation, which would occur at the point of aphelion might soon lead to chemical action. Precipitation might ensue, and the necessary consequence would seem to be a continually accelerated communication at this point, which would terminate in the production of a planet.

Prof. MITCHEL asked, whether there was not a possibility that this alleged fluid ring, in its changes of configuration, might run into a fluid sufficiently thin to give the possibility of the transmission of light through it. If it really change its form and become several rings, it seemed that in the act of passing from one single ring to two, before it divided, it must become so thin as to allow the light to penetrate and come to us refracted. If this should prove to be the case, the Professor considered it of the utmost importance, and every observer should carefully observe the occultations. He considered it a very strange and curious doctrine.

Prof. PEIRCE replied that it was of course almost impossible to

answer the question of Prof. Mitchel. He supposed, however, that at the moment of separation a sinking takes place, producing a depression at the point where the separation takes place, and that rapidly after it begins, it goes on to the reduction of two rings. It was doubtful whether the refraction would be sufficient to reach the earth.

Prof. SCHAEFFER proposed a query, whether the precipitation of so large a body of water as had been determined by Prof. Peirce, upon the body of Saturn, would not be likely to produce a deluge?

Prof. PIERCE said the larger portion of the fluid had probably gone off, leaving but a small part in contact.

2. ON THE AGE OF THE SANDSTONE OF LAKE SUPERIOR, WITH A DESCRIPTION OF THE PHENOMENA OF THE ASSOCIATION OF IGNEOUS ROCKS. BY MESSRS. FOSTER AND WHITNEY, U. S. Geologists for the Lake Superior Land District.

THE true geological position of this sandstone, has often been the subject of discussion; and various are the opinions which have been given by different geologists on this point. Captain Bayfield was the first to explore this formation, while conducting the Trigonometrical Survey of Lake Superior. In an article in the Quarterly Journal of the Geological Society of London, for November, 1845, "on the junction of the Transition and Primary rocks of Canada and Labrador," he remarks, "No organic remains have as yet been found in the sandstone, and its junction with the Lake Huron limestone in the River St. Mary's, below the rapids, being hidden by drift, water, or an almost impervious forest, so as, hitherto, to have escaped notice, it is difficult to determine, with any confidence, its place or age. There seems to be no reason to think that it can be more recent than the old red sandstone; and when it is considered that it appears in the St. Mary's at low levels, forming nearly horizontal strata in the bottom of Lake George, whilst the horizontal fossiliferous limestone of Sugar Island and St. Joseph's rises into higher ridges, so as to make it appear *highly probable* that the sandstone occupies the inferior position; and that, moreover, a sandstone is known very generally to underlie transition limestone, in Canada and the United States;—when all this is taken into account, it is perhaps not unlikely that the sandstone in question may belong to the Silurian, rather than the Devonian period. On the other hand, its appearance in unworn slabs in the neighborhood of Michilimackinac, where great beds of gypsum occur, would seem unfa-

vorable to this conclusion; as may also, perhaps, the red marly beds of the Twelve Apostles."

On the geological map of township lines in the northern peninsula of Michigan, surveyed by W. A. Burt, Esq., under the direction of Dr. Houghton, in the year 1845, (which is published in the 3d volume of the documents accompanying the President's message for 1849–50,) this sandstone on the south side of the axis, where it crosses the Esconaba River, is laid down as the Potsdam; while the Calciferous sandstone, and the Birds-eye and Trenton limestones, are represented as overlying it. The superposition of the rock from the mouth of the Esconaba to the shore of Lake Superior, was determined by Dr. Houghton; and there is no doubt that he had fully satisfied himself as to the true position of the rock along that line.

Dr. Owen, in his report on the Chippeway District for 1848, pp. 57 and 58, remarks, that in the absence of all conclusive evidence derived from organic remains, there is certainly strong presumptive evidence that the red sandstone marls were deposited subsequently to the carboniferous era.

Dr. Jackson, in his report communicated to the Land Office in 1849, and published in the 3d volume of the documents accompanying the President's message for 1849–'50, describes this sandstone, including the sandstone of the St. Mary's River, as the *New Red,* and seems to regard it as established that it can not be the Potsdam. In his various previous publications on the geology and mineralogy of the Lake Superior region, he had expressed the same opinion. At a meeting of the Boston Natural History Society, on the 2d of October, 1850, he expressed the opinion that the age of all the Red sandstones of this country was questionable; that the Red sandstones of the Connecticut River Valley, Nova Scotia, and Lake Superior, were all of the same age, and that "they were not the same as the New Red sandstone (properly so called) of Europe, but belonged to the Silurian system." This opinion, he remarked, was confirmed by a recent examination of the fossils by Mr. Wells, of Cambridge, Mass.

Dr. Locke, in his report to Dr. Jackson for 1847, calls this sandstone the "Old Red," but seems to have had a correct idea of its position at the base of the Silurian, although he gave to it the name of a group of rocks *above* the Silurian.

Mr. Foster, in his synopsis of observations between Lake Superior and Green Bay, published in the Report of the Commissioner of the Land Office for 1848, describes the sandstone as resting at the base of

the Palæozoic series, and as the equivalent of that of the northern slope.

That same year, Mr. Murray, of the Canada Survey, examined the north shore of Lake Huron, and satisfied himself that the sandstone of the St. Mary's and the adjacent region, passed beneath the Trenton limestone. In reference to his explorations, Mr. Logan remarks, that "the evidence afforded by these facts is clear, satisfactory, and indisputably conclusive."

Thus it will be seen that the most reliable observers had agreed on the position of the sandstone at the St. Mary's River, and on the Southern Slope of the axis, and had correctly considered it as representing the Potsdam sandstone of New York, and lying at the base of the lowest known fossiliferous groups of stratified rocks. Other observers, who had crossed the Lake from Sault St. Marie to Keweenaw Pt., and had there seen the greatly increased thickness of the sandstone deposits, and the immense accompanying belts of conglomerate, had failed to recognize in them the same rocks which they had seen lying nearly horizontally, and exhibiting no appearance of having been deposited under circumstances indicating violent action of fire or water. They were at a loss to understand how the same formation could, at points not very widely separated from each other, assume characters so different. Add to this, the uncertainty arising from the total absence of any organic remains in the sandstone and conglomerates of Keweenaw Pt., and we have some reason for the hesitation which was felt by geologists in regard, particularly, to the age of the sandstone of Keweenaw Pt. and Isle Royale. Had the same geologists once fully convinced themselves of the position of this rock at the St. Mary's River, and then coasted along the southern shore of the Lake to Keweenaw Pt., they would undoubtedly have felt less hesitation in acknowledging that the strata which they thus traced along, almost continuously, and which they saw gradually expanding in thickness, and assuming a metamorphic appearance as they approached the line of igneous rocks, was in reality nothing but the same formation which they had started on, locally modified by a powerful cause.

It remained, then, for us, in attempting to solve completely the problem of the position of the Lake Superior sandstone, to trace it continuously from the River St. Mary's west to the great azoic and granitic belt; thence around its southern side, where it retains its unaltered character, and also on the northern slope of the axis, along the coast of Lake Superior, as far as our district extended, observing

its changing character, and endeavoring to trace out the relation of these changes to the immense trappean belt which stretches from the extremity of Keweenaw Pt. to beyond the Montreal river.

In thus demonstrating, by the evidence of superposition, the true place of the sandstone at the Sault, and along the whole line of its junction with the lower Silurian, through the whole extent of the northern peninsula of Michigan to the Menomonee; in proving its continuity and identity along the whole southern shore of Lake Superior; and lastly, by tracing out the changes it has undergone from local causes increasing its thickness, and introducing immense beds of conglomerate in the intercalated beds of trappean rock, we consider that although the palæontological evidence may be wanting or obscure, yet there can no longer be any doubt that this sandstone lies below the lowest fossiliferous members of the Silurian, in the position of the Potsdam sandstone of New York.

We will now proceed to some of the details of our observations in regard to the points thus hinted at; and we will first give some facts with regard to the nature and position of this formation on the southern side of the azoic and granitic region, commenced at the eastern extremity of our district.

At Sault St. Marie, the river falls twenty-one feet in the distance of a mile, over this rock, which is exposed at the head of the rapids, and on the islands in its bed. It is very fissile, of a brick-red color, interspersed with light colored blotches. It here dips, as observed elsewhere, away from the granite axis, which occurs on the opposite or Canadian side of the river. The junction of the sandstone with the calciferous, is supposed to occur near the southern end of Sugar Island, but the accumulations of drift have covered up the subjacent rocks. Mr. Murray, of the Canada Survey, has traced it along the northern shore of Lake Huron, where it is seen, as in our district, in a nearly horizontal position, filling up the hollows in the quartz rock; "but in many places," he remarks, "the irregularities in this ancient bottom are so great that different members of the fossiliferous group come in contact with it."

The ancient land, from which these arenaceous beds were derived, lay to the north-west; there they acquire their greatest expansion, and thin out as traced to the south-east. It is probable that, along the St. Mary's river, the thickness of the Potsdam and Calciferous sandstone combined, does not exceed a hundred feet. Mr. Murray estimates

the former at forty feet, but does not seem to have recognized the latter in this part of his district.

The south-westerly prolongation of this sandstone along the southern side of the granite, the eastern termination of which is near Chocolate River, is to be traced along at various points, but obscurely, owing to the heavy accumulation of drift materials upon it. Mr. Burt describes it as a coarse quartzose rock, generally red, but in some places mottled, and in others of a yellowish color. Near the Menomonee, it is seen in a nearly horizontal position, with isolated patches of the Calciferous sandstone superimposed upon it. Where it crosses the Menomonee, the belt is about fourteen miles in width, and it has a gentle dip, corresponding with the inclination of the country, since the subjacent slates and the associated igneous rocks are exposed in the bed of the river for ten miles after the sandstone is intersected. All along this distance the sandstone rests with a gentle dip to the south-east, not exceeding three degrees, on the vertical edges of the slaty rocks, and the compact and crystalline igneous rocks, which are intercalated among them. The sandstone is generally white, or slightly tinged with red, and exceedingly friable, being composed of grains of quartz, slightly rounded, and sometimes presenting crystalline facets, which are united together with hardly any trace of cement. In fact, the rock often consists almost wholly of pure quartz, as is shown by an analysis of a specimen from the White Rapids of the Menomonee, which yielded 99.7 per cent. of silica, the remaining .3 being alumina, with a trace of peroxide of iron and lime.

As far as observed on this side of the district, this sandstone appears to be destitute of fossils, though Lingulæ were found by Mr. Hall on the Esconaba, at the base of the Calciferous sandstone, or top of the Potsdam ; also, a trilobite, resembling one figured by Mr. Owen, from about the same geological position, found at Stillwater, on the St. Croix.

If, now, we proceed from Sault St. Marie westerly, along the southern shore of Lake Superior, we find the sandstone occasionally exposed at the base of the islets and in low reefs in Tequamenon Bay, but in general concealed by a heavy mass of drift, till near the Pictured Rocks, where it presents a mural front to the lake for a distance of between five and six miles, and rises to a hight of from one hundred to nearly two hundred feet perpendicularly from the water. This line of rock is not by any means continuous in a straight line, but is broken up by advancing and retreating masses, or worn into curved outlines.

In the precipitous cliffs thus formed, the action of the water at their base has hollowed out numerous arched openings and vaulted cavities, some of which are most intricately and elaborately formed, and of vast dimensions. The Grand Portal, so called, presents a front opening to the lake of a hundred feet in hight, and nearly one hundred and seventy in breadth at its base. Within, it opens into a magnificent dome-shaped vault, with smaller arched passages on each side, presenting one of the most grand and striking objects of natural scenery in the country. Other points of interest, which, though less grand in their outlines, are still more curious in form, are the Chapel, a vaulted roof of rock, supported on massive columns, and provided with a curious niched cavity resembling a pulpit, and an isolated tabular mass which is called the altar, and the Miners' Castle, an isolated rock, worn into the form of a Gothic archway or portal of a castle. In fact, the variety of strange and grotesque combinations of form, and the beautiful ornamenting of color, combined with the majestic forests which crown the cliff above, at a hight of two hundred feet, with the pure and deep green water of the Lake beneath, thundering and dashing into the hollow openings, and against the unbroken face of the rocks—all these form together a series of picturesque scenes, unlike any thing which can be seen elsewhere, and truly worthy of the visits of the lover of the grand and beautiful in nature. A few fucoidal impressions, first observed by Dr. Locke, are found in the sandstone at the Grand Portal. They are considered by Mr. Hall as plants, analagous to the genus described by him under the name of *Palæophycus*, occurring in the Calciferous sandstone of New York. These impressions, together with a few specimens of Lingula, found by Mr. Forrest Shepherd in Tequamenon Bay, are all the organic remains as yet discovered in this sandstone.

The rock is in general rather coarse-grained, the separate grains being somewhat rounded, and crumbling readily under the touch. The strata have a slight dip to the south-east. In many places, the phenomena of cross-stratification are finely displayed—successive beds being made up of a great number of finer layers, inclined at different angles, the result of a deposition among the shifting currents of shallow water.

The name by which the Pictured Rocks are known to the voyageurs, is "Les Portails," a term derived from the arched and portal-like cavities worn in the base of the cliffs. The term "Pictured Rocks," by which they have been known in the English language for a long time, though by whom it was first given we have not been able to ascertain,

alludes to the banded stripes of various hues of color, which ornament the lower part of the cliffs at various points. These colors which are principally deep shades of red and brown, blue, bluish-gray, and yellow, are arranged in parallel vertical stripes, along some twenty or thirty feet of the lower part of the vertical, or nearly vertical, wall, and are due to the oozing out of water charged with coloring matter, from thin clayey or marly beds in the sandstone, containing the oxides of iron, and probably, copper.

As far as the mouth of Chocolate river, we find the sandstone continuous along the coast, or it may generally be found at a short distance back from the lake ; when directly on the shore, it is covered by drift. Between Chocolate and Carp rivers, however, the quartz rock of the azoic group makes its appearance, and the sandstone is seen lying unconformably upon it, and filling the hollows and depressions in it. The sandstone rests nearly horizontally upon the vertical edges of the azoic rock, or, at most, is slightly disturbed and fractured near the junction, indicating very little relative change in the position of the two rocks, since the deposition of the newer.

For a distance of about ten miles, namely, to just beyond Granite Point, the sandstone is broken in its continuity, as the azoic slates and the associated igneous rocks, occupy the greater portion of the line of the coast in that interval. There is every reason to believe, however, that the sandstone was originally deposited continuously around the azoic rocks which occupy this space, since we find patches of it still remaining, and abutting horizontally against the projecting promontories of igneous rocks, where, from its situation, it has been protected from abrasion. At Presqu' Isle, the sandstone rests upon a singular igneous mass, composed of a silicate of iron and magnesia, and containing nearly ten per cent. of water. At Middle Island it is seen reposing on the granite, with an inclination of 7° to the S. E. Insulated patches are never met with at a greater elevation than 350 feet above the lake, and hence we infer that the more elevated portion of the granites and slates rose above the surface of the ocean, in which the sandstone was deposited.

Granite Point presents one of the most instructive sections to be met with on the whole coast. A dome-shaped nucleus of granite, (composed principally of quartz and feldspar,) rises to the hight of seventy or eighty feet, exhibiting, when the overlying sandstone has been denuded, a polished and rounded outline, like a reef by the sea-side, over which the surf has rolled for centuries. Upon the ancient surface

the sandstone was deposited in a nearly horizontal position, although many beds exhibit beautiful instances of cross stratification. Dykes of greenstone of great magnitude traverse the granitic mass, but do not penetrate the sandstone. Fissures, however, are observed to extend from one rock into the other, and, for a few inches on each side of these cracks, the sandstone has been deprived of its coloring matter, so that at a little distance the rock seems to be traversed by regular and parallel veins of calc-spar. This appearance is probably due to the escape of gases from below, which have reduced the peroxide of iron to the protoxide, thus discharging the color on each side of the fissure for a short distance into the rock on each side.

From Granite Point, the sandstone extends uninterruptedly along the lake shore, with a width of from one to four miles, as far as the bottom of Keweenaw Bay, forming low cliffs on the east side of the bay. At the Anse it is seen reposing unconformably on the slates. In the vicinity of the Anse, the strata, wherever seen in place, are nearly horizontal, and they continue in this position till we arrive in close proximity to the trappean rocks in Bête Grise Bay.

Having thus noticed some of the more interesting facts connected with the sandstone, and demonstrated its continuity of deposition as one formation around the great central granitic and azoic nucleus, we shall now proceed to consider it in its relation to the contemporaneous trappean rocks which accompany it from the extremity of Keweenaw Point westward, and on Isle Royale. Apart from the influence of the contemporaneous igneous rocks, in what may be called its normal state, we have seen it reposing horizontally, or nearly so, in beds of a granular quartzose material, mostly friable, and containing little iron. We have seen that the thickness of the whole formation, did not exceed 100 feet at Sault St. Marie, and that at the Pictured Rocks it was not probably greater than 300 or 350 feet, gradually increasing from the east toward the west.

In the vicinity of the trappean rocks, on the other hand, we find the sandstone developed to a great thickness, and accompanied by wide belts of conglomerate; we find it becoming impregnated with oxide of iron and calcareous matter, and intersected by numerous veins of calc-spar and baryta, and containing native copper and its ores; we find it interstratified with beds of igneous rock, in numerous alternations, which beds have successively flowed over its surface, and been again covered by sedimentary material; we find the whole system of conglomerate, sandstone and bedded trap, lifted up at an angle which

gradually increases as we approach the central igneous mass, and from which it dips on each side.

We will first briefly sketch the principal features of the trappean rocks, and then pass on to the consideration of the sedimentary rocks connected with them.

Commencing at the head of Keweenaw Point, we find the trappean rocks presenting a bold and picturesque front to the lake. The outer belt, occupying the extreme northern portion of Keweenaw Point, is somewhat less than a mile in width, and extends westerly about 18 miles, to Sand Bay, when it is intersected by the lake and disappears. Throughout most of this distance it is protected from the waves by a broad band of conglomerate to the north, but at several points the water has broken through the sea-wall, and excavated spacious harbors in the igneous rock: Copper-Agate, Eagle and Grand Marais Harbors, owe their origin to this cause. The belt of trap, though traversed by veins containing copper, has afforded little encouragement to mining enterprise.

About a mile south of the above-described belt of trap, and separated from it by a deposit of coarse sandstone and conglomerate, which in places expands to a width of more than 3000 feet, occurs the northern great trap range of Keweenaw Point, preserving a remarkable parallelism throughout its course with the other.

This range does not appear to have been the result of one, but of several successive overflows, for we not only find the igneous materials arranged in parallel bands, and exhibiting great diversity of external character, but we also find numerous intercalations of conglomerate and sandstone of inconsiderable thickness, but extending for miles in a linear direction, these mixed products being associated in regular beds, having a common bearing and inclination.

This range starts from the head of Keweenaw's Point, and, sweeping round in a crescent form, conforming nearly to the trend of the coast, it extends the whole length of the Point, and crosses Portage Lake, beyond which it sinks down, and is covered, in a great degree, by accumulations of drift, so that it seems to lose its distinctive character, and only appears above the surface in occasional knobs. It attains an elevation, at its highest point, of about 800 feet above Lake Superior. We will illustrate the character of the bedded trap, and the sandstone, by referring to the section displayed at the Copper Falls Mine, where there are five repetitions of these rocks in the space of 2000 feet; the beds of trap having the thickness, proceeding from north to south, of

400, 50, 436, and 60 feet, while the accompanying beds of sandstone are, respectively, 450, 50, 60, 200 and 15 feet in thickness. The whole system dips to the north, at an angle of about 26°. Between the mouth of Eagle River and the Phenix Company's works, no less than eleven of these belts, thus intercalated, are noticed within the space of about a mile.

It is this northern range of trappean rocks in which are situated the productive mines of copper of Keweenaw Point. The veins traverse the formation nearly at right angles to it; the mean of several veins being, north, 21½°, west —, and some, if not all of them, cut through the igneous and sedimentary rocks; undergoing marked changes, however, in the character of the gangue and quantity of the copper, as they pass from one formation to another, or even from one variety of trap into another adjacent one, of a different lithological character.

Returning to the head of Keweenaw Point, we find another range of trap, forming the southern boundary of the valley of the Little Montreal River, and stretching westerly in a line nearly parallel with the northern chain. This range differs from the other, both in its lithological character and in its mode of occurrence. While the northern range, as before described, is made up of numerous beds of trap, in the main, of the amygdaloidal and granular varieties, interstratified with the detrital rocks, the southern range consists of a vast crystalline mass, forming an anticlinal axis, and flanked, on the north, by the bedded trap and conglomerate, and on the south by the sandstone and conglomerate. The contour of this unbedded trap is very different from that of the bedded; we do not recognise in it that stair-like structure, characteristic of the latter. The outlines of the hills being more rounded, or dome-shaped. Its associated minerals, and ores, are different; it is not characterized by veins of native copper, but this metal occurs in it as a sulphuret.

Beyond Portage Lake, the trap range extends in a belt of from three to twelve miles in width, in a line nearly parallel with the coast, and at a distance from it varying slightly, according to the irregular curving of the lake shore, but, generally, about ten or twelve miles. Between Portage Lake and Fire-steel River, it appears rather in isolated knobs, and is mostly covered by drift, but in the vicinity of the Ontonagon it rises again into bold cliffs. Near Agogebic Lake, a spur shoots off to the north, gradually curving to the east, and rises to a hight of nearly 1400 feet in the Porcupine Mountains. To the west of Agogebic Lake, the cliffs sink down; and though the range preserves its course, and

increases in width, it is more broken in its character, and rarely exposed in good sections. It is not productive in copper, here; and the few companies which have attempted mining in the Porcupine Mountains, and in the main trap-range west of Agogebic Lake, have long since abandoned the work. The best natural section of the trappean rocks, in the western part of our district, is afforded by the Montreal River, its western boundary, where the alternations of sandstone, or shale and bedded trap, as also the conglomerate, are finely displayed, in a deep gorge worn by the river, directly across the range.

The trappean rocks of Isle Royale are almost exactly the counterpart of those on Keweenaw Point, except that they, with the associated sandstone and conglomerate, dip to the south. They are characterized by the same banded structure, and contain the same metallic products. There are, however, minor differences. Different systems of fracture are found to prevail on Isle Royale, and the conglomerates are not developed on so grand a scale; but, on both shores, the lines of inclination converge to a common center, forming a deep, synclinal valley, which is occupied by the waters of Lake Superior.

Having thus briefly indicated the position of the igneous rocks, with regard to the sedimentary, we proceed to speak of the modes of occurrence of the latter class, and the changes which the two have undergone in their proximity to each other.

The conglomerates of Keweenaw Point, and Isle Royale, consist of rounded pebbles and masses of trap, almost invariably of the amygdaloidal variety, derived, probably, from contemporaneous lavas, and rounded fragments of a jaspery rock, which may have been a metamorphosed sandstone; the whole cemented together by a dark red ferruginous sand. This cement may be regarded as a mixture of a volcanic ash and arenaceous particles; the latter having been derived from the sandstone then in the progress of accumulation. It is not unusual to meet with strata, composed entirely of arenaceous particles, associated with the conglomerate beds; and when these expand to a considerable thickness, the associated sandstone appears in alternating bands of red and white, and exhibits few traces of metamorphism: but when the belts of sedimentary rock are thin, and come in contact with the trappean rocks, the sandstone is converted into jasper, and becomes traversed by divisional planes.

We are strongly inclined to the belief that the origin of the conglomerate is not due, solely, to the action of waves and currents, which have broken up, and rounded, and polished, the trappean and jaspery

masses of which it is composed: on the contrary, we believe that the greater portion of these immense deposits are the result of an igneous, rather than an aqueous force. The rounded masses, in the conglomerate, often attain a magnitude of eighteen inches in diameter, and their surfaces do not always present that smooth and polished appearance which results from the attrition of water. In fact, a close observer can, in most cases, readily distinguish between those pebbles which have been recently detached from the rock, and those which have been, for a time, exposed to the action of the surf. The conglomerate seems to have been formed too rapidly to allow of the supposition that their origin was purely aqueous; for while the contemporaneous sandstone, remote from the line of volcanic action, does not exceed three or four hundred feet in thickness, the united thickness of the conglomerate bands, in the vicinity of the trap of Keweenaw Point, exceeds 5000 feet. As we recede, for a few miles, from the igneous rocks, the conglomerates disappear, entirely, as separate members of the formation, and are only found in very thin and insignificant patches, amidst the sandstone.

We have little hesitation, therefore, in adopting the views of Von Buch, as to the origin of such masses of rounded materials in the vicinity of igneous rocks, and consider them as the result of the friction and mechanical action caused by the volcanic action along the line of fissure. We can hardly conceive of the displacement of such enormous masses of igneous matter as have, during a long period, been flowing over the depositing beds of sedimentary matter, without supposing violent dislocation, and crushing of the previously deposited strata. Immense quantities of material would be loosened, and torn off, along the line of volcanic outburst, and would gradually become rounded by friction against each other. Those pebbles which have a vesicular structure may have been ejected as scoriæ, while in a semi-fluid state, and have received their rounded form while falling through the air, like volcanic bombs. Whether it be allowed, or not, that such conglomerates could have been produced, solely, by igneous or volcanic action, it must be evident to every one that, in this way, materials would be heaped together, and broken up, so that, under the action of strong currents of water, they would soon assume a rounded form. In fact, these very currents must have been caused, or increased vastly in intensity, by the same volcanic action which produced the igneous rocks.

The conglomerate rocks (and the same is true of the sandstone in the vicinity of the trappean rocks) are found to be traversed by different systems of divisional planes, which preserve a remarkable degree

of uniformity in their direction, and extend to unknown depths. The course of the main fissure is nearly north and south.

The conglomerates attain their present development on Keweenaw Point, where all the phenomena combine to prove the highest volcanic activity during the deposition of the sandstone. As we follow the shore of Lake Superior westward, we find the sandstone gradually becoming more nearly horizontal, and showing fewer signs of metamorphism, as its distance from the trappean rocks increases; for instance, in the vicinity of Salmon-trout and Elm rivers, where the distance from the Lake shore to the trappean range is about six miles, and where the elevation of the latter is but slight, we find the sandstone having a dip of not more than from three to five degrees, toward the north, northwest. At the base of the Porcupine Mountains, on the other hand, where the trap approaches within a mile of the coast, the sandstone dips 30° to the northwest. Patches of conglomerate are occasionally seen flanking the trap, along the whole course of the range, to the Montreal River, where, as before-mentioned, it attains a thickness of over eighteen hundred feet. At this point, the dip of the sandstone and bedded trap is almost vertical, from the line of junction of the trap and sandstone to the Lake shore. This would indicate an enormous thickness of the sandstone at this point, the strata dipping nearly vertically, for a width of between two and three miles; which is an exception to the usual rule, by which we generally find the dip of the sandstone diminishing rapidly, as we recede from the trappean range. We are unable to explain, fully, this anomalous development of the sandstone just on the western borders of our district. Perhaps further explorations to the westward will clear up this point. We can, however, see no sufficient proof that it does not form a portion of, or that it is of a more ancient period than, the sandstone further east. It must be noticed, however, that in this part of the district the sandstone is wholly confined to the north side of the trap range; no sedimentary rock interposed between the trappean rocks and the granite occurring west of Black river. The belt of trappean rocks, moreover, has a much greater width to the south of the Montreal river than in any other point in our district; a spur from the east, of two or three miles in width, joining the main range, which occupies a width of about six miles near Black river. West of Montreal river, the trap recedes from the Lake shore, and the sandstones gradually approach horizontality in their position.

The alternation of trap and conglomerate which we have described,

are, for the most part, confined to the north side of the trappean range; on the southern slope these belts are comparatively rare. Where the Bohemian range breaks through the incumbent rocks at Lake La Belle, a thin band of conglomerate is observed, not exceeding thirty feet in thickness, and which has been traced at intervals for two or three miles. The inclination is 80° to the south and south-east. The whole mode of action of the dynamic forces on the north and south side of the trap range, seems to have been different. On the north side, we not only find the bedded trap, and immense deposits of conglomerate above described, which rarely occur on the south; but we have a material difference in the character of the dip of the sandstone in the two slopes. On the north, the sandstone and conglomerate dip at angles rarely exceeding 40° in the immediate proximity of the trap, and this dip gradually diminishes as we recede from the center of elevation, so that a gently descending slope is formed, which extends regularly from the highest point of the igneous rocks to the lake shore. This is particularly the case to the east and west of the Ontonagon, where the descent of 400 or 500 feet from the trap to the lake, is so gradual and regular as to be hardly perceptible. The mural faces of the trappean ranges are, almost without exception, turned toward the south, and we find the sandstone on that side elevated at a high angle, dipping almost vertically sometimes, just at the junction of the two formations, but as we proceed southward, almost immediately becoming horizontal again. The appearance is as if the strata had been broken and elevated just at the southern edge of the igneous mass; while but at a short distance from it, in that direction, no disturbing force was acting during their deposition. To account for this phenomenon, we must suppose that the line of igneous activity was along the northern edge of the trappean range, and that afterward, during the protrusion of the more southern portion of the trap, that of the Bohemian Mt. or Keweenaw Pt. for instance, the up-heaving action was confined principally to the region on the north. Thus, while a gradual elevation of the bedded trap and conglomerate was going on just north of the central fissure, a corresponding depression was taking place still further north, and the reverse of all these circumstances was taking place in the line of Isle Royale. The great synclinal trough, or basin, of Lake Superior was the result of this combined action of elevation and depression.

The changes which have taken place in the structure and lithological character of the sandstone and trap, are of an interesting character, and throw much light on the mode of formation of the trappean beds.

The upper portions of the sheets of the bedded trap are often highly vesicular, resembling pumice. Fragments of amygdaloid, sometimes rounded, at others angular, are found inclosed in the pumice-like trap; as though they had become detached from, and afterwards re-united to, the mass while in a soft state. Numerous short and irregular fissures, extending to no great depth, are observed on the upper surface of the trap, and in which the sandstone has been deposited. At the junction of the two rocks, where the sandstone lies *above,* it is extremely difficult to determine where one begins and the other ends, and there is little appearance of metamorphism in the sedimentary rock; but, on the other hand, where the trap is the overlying rock, the line of junction is clear and well defined. The trap in this case is more compact, and the sandstone, for a distance of three or four feet, is converted into a jaspery mass. These phenomena have been observed at numerous places, both on Isle Royale and Keweenaw Pt. The beds of sandstone are not shattered, nor does the igneous rock penetrate them in the form of dykes or ramifying veins. All the phenomena indicate that the igneous rocks were not protruded in the form of dykes between the strata, but that they flowed like lava sheets over the prëexisting surface, and that the sandstone was deposited on the surface of the igneous mass, in some cases, while the latter was still in an incandescent state.

To return now to the evidence touching the geological position of the sandstone of the southern shore of Lake Superior. We have seen that its continuity and identity with the sandstone of Saut Ste. Marie, and the southern slope of the granitic axis, can not be doubted, while the position of the latter, at the base of the Silurian series, has been repeatedly observed. Although no further evidence would, in reality, be required, to allow us to consider the question settled, yet we have still remaining, upon the northern side of the axis, a small deposit of lower Silurian limestone, resting upon the sandstone, which effectually completes the chain of evidence, and leaves no further doubt in the matter.

The whole of the northern slope of the anticlinal axis bears evident marks of having been subjected to extensive denudation; and hence, over the greater portion of this region, we look in vain for traces of limestone rocks; if they existed, they have been swept away; and wherever we penetrate through the thick deposits of clay and sand, we find the rock in place to be sandstone. A limited patch of limestone still remains west of the Anse, occupying a portion of four sections in township 51, range 35. This limestone forms a bluff some 200 feet, in its highest point, above the surrounding country, and is

the highest land in that region; it is distinctly stratified, of a light buff color, and magnesian. Near the quarter-post between sections 13 and 14, in the above township, the limestone appears in a precipitous ridge, and is nearly horizontally stratified. It here rests on the white sandstone belonging to the upper part of the formation, which has been described above. A little further south the same limestone is seen, in a bluff extending in a curved line near the line between sections 23 and 24; here, however, it dips toward the east at an angle of from 25° to 30°, forming cliffs from 25 to 50 feet in hight.

From the horizontality of the first mentioned deposit, which occurs about a quarter of a mile to the north, it seems evident that the limestone overlies the sandstone, although the position of the inclined beds of the more southerly portion of the limestone is at first difficult to explain, since the surrounding country is low, and underlaid by sandstone in horizontal strata. It seems evident that at this point the rocks have been disturbed and upheaved by igneous action beneath, which has raised the strata, without any appearance of trappean rocks on the surface. This view of the case is corroborated by the fact, that at no great distance from this point an elevation occurs, from which the strata of sandstone dip on all sides; and although there is no igneous rock visible, yet it is evident that the sandstone has been raised in a dome-like protuberance, by a mass of igneous rock pressing upward from below. The same cause is indicated by the unusual disturbance of the magnetic needle in this vicinity, observed by the linear surveyors, which is generally caused by the proximity of trappean rocks. The isolated knob called Silver Mountain, not far distant from this limestone, affords an instance where the trap has not only raised and shattered the strata, but has had sufficient force to cause the protrusion of the igneous rock, and the formation of an elevated conical knob.

The fossil remains entombed in this deposit of limestone, are by no means abundant, and are so imperfect, consisting for the most part of casts, that it is impossible to identify species. Such as were collected by us, some ten or twelve species, were submitted to the examination of Mr. James Hall, who did not hesitate to pronounce them Lower Silurian, representing groups of that series not more recent than the Hudson river group. Among these fossils were a species of Maclurea, resembling the Maclurea from the Chazy limestone; Murchisonia; Ambonychia, a species resembling *A. orbiculata* of the Trenton limestone; Modiolopsis, closely allied to *M. truncatus;* Edmondia, probably *E. ventricosa,* and another species, closely allied to or identical

with a species from the Trenton limestone; Leptæna, resembling *L. sericea,* which does not occur above the Clinton group; Orthis, with lower Silurian characters; joints of Crinoids, of the genus Glyptocrinus, not more recent than Hudson river group.

We have thus presented, in as concise a manner as possible, some of the leading facts with regard to the occurrence and position of the sandstone and conglomerate of Lake Superior, and their relation to the associated trappean rocks; and we trust that we have solved satisfactorily some of the problems presented by these rocks. We have been obliged to omit many points of interest; the discussion we may be able to take up at a future meeting of the Association.

In reply to Mr. Foster's statement of having seen only trappean overflows, and no dikes on the south shore of Lake Superior, Major OWEN said:—"He could not speak decidedly of the south shore of Lake Superior, having examined it only as far as the Bois Brulé River, where the two surveys united; but having spent one season in examining the north shore, he could state that *there* two distinct trappean upheavals, probably the result of submarine volcanoes, could be traced. The one had evidently been the result of overflow, sometimes exhibiting an approach to imperfect bedding, sometimes for miles displaying a rude columnar structure, with its columns at right angles to the cooling surface, and varying from pentagonal to octagonal in form, resembling, in many points, the description of the Giant's Causeway. This overflow was further characterized by *overlying* the sedimentary and metamorphic rocks, and by having a general bearing nearly northeast and southwest. The other had a direction nearly at right angles to the former, and had cut up through the sedimentary and metamorphic rocks, in remarkably regular dykes, resembling the work of art. These dikes varied in width from six to ten feet, the columns lying horizontally across the dike, at right angles to the cooling surfaces through which it passed. These dikes were usually of greenstone, sometimes of basalt; generally highly crystalline in the center, less so toward the contact with the rocks through which they had cut, and partaking in some measure of their structure. The stratified and metamorphic rocks cut through, were usually altered for many feet on each side of the dikes, by causes evidently due to strong igneous action. It was in these last mentioned upheavals, the dikes, that metallic veins and accompanying minerals were most generally found, as may be observed at Prince's location, at the Bruce Mines in Upper Canada, and at various other localities."

3. On the Gephyrea of the Atlantic Coast of the United States. By L. F. de Pourtalès.

The Sipunculidæ have been usually placed among Holothuriæ, and on that account I have studied them in connection with that family, but soon satisfied myself that their title to rank in it was very precarious. They form, indeed, a group bearing some analogies with Holothuriæ, and some with the worms or annelids, and they have been accordingly classed by naturalists, sometimes with the one and sometimes with the other. It was at first my intention to give a short historical sketch of this group, and some of the anatomical details on which I took my grounds for considering them as annelids, when I found that the same labor had already been done by Quatrefages, in his anatomy of Echiurus,* to which I would refer those who take any interest in the matter. Quatrefages unites in a group which he calls Gephyrea, *Echiurus* and *Sipunculus*. That they are truly articulated animals, can scarcely be doubted : their nervous system consisting in a ganglion above the esophagus, connected by nervous filaments to a nervous cord running the whole length of the lower part of the body, and giving branches in pairs to the right and left ; their perfect bilateral symmetry, the want of any quinary arrangement, the absence of calcareous parts in the skin, or around the esophagus ; their trunk exertile and retractile ; all those characters assign them a place among the annelids. With Holothuriæ they have also analogies, not, however, so important. These are, in Echiurus for instance, the disposition of the spines all around the body at its posterior extremity ; in the Sipuncles, the disposition of the tentacles surrounding the mouth, and the presence of the vesicle of Poli. This group thus forms the most remarkable transition in the animal kingdom.

Genus Echiurus—*Pallas.*

Mr. Couthouy has described a species of this genus under the name of *Holothuria chrysacanthophora.* We shall in future call it

Echiurus chrysacanthophorus. I have seen but a single specimen of this species, in the possession of Dr. A. A. Gould. It would be desirable to compare perfect specimens with *Echiurus Gaertneri* of Europe, in order to trace their specific difference. The one I have

* Annales des Sciences Naturelles, 3me Sér., 1847.

before me answers very well to the characters assigned to *Ech. Gaertneri* by Quatrefages. It wants likewise the spoon-shaped appendage.

Genus Sipunculus—*L.*

The genus Sipunculus has lately been divided into two, one of them retaining that name, the other being called *Phascolosoma.* J. Muller characterizes them by the insertion of the large retractor muscles of the trunk, which in Sipunculus have their posterior insertion about the middle of the body, while in Phascolosoma it is situated at the posterior extremity.

Of the genus Sipunculus, notice first one species, from the coast of New England, which I propose to call

2. *Sipunculus Gouldii* (Pourt). I found it first at Provincetown, (Cape Cod,) and afterwards at Edgartown and Chelsea Beach. It lives burrowed nearly one foot deep in the sand, and is secured by digging into it at low tide. It attains a length of five or six inches, with a diameter of a third of an inch, and resembles in the whole *Sipunculus Johnstoni* of Forbes. It has a whitish color, yellow toward the first posterior extremity; the extremity of the trunk is pink; the skin, at sight, looks as if it were perforated with numerous little sieve-like holes, but a closer examination shows that they are only apparent perforations, the skin being in those places very thin and transparent. Under the skin are two muscular layers, the outer one composed of transverse fibers, the inner one of longitudinal ones, forming about forty bundles. Of the retractor muscles of the trunk, the two inferior ones are the longest, and attached side by side to the walls of the body, separated only by the nervous cord. The two superior ones are attached to the sides of the body a little higher up. The mouth is surrounded by a great number of short tentacles, in which the microscope shows an active circulation of blood, apparently produced by vibratory ciliæ lining the inside of the cavity. The inside of the cavity of the body itself, is filled with a pinkish fluid, in which the microscope shows the eggs floating in great number. Eggs are also found within a red filiform and odd organ, which follows the intestine, and which is probably the ovary in which they are formed. In the brown bags, which open outside a little higher up than the anus, globules were found, somewhat similar in appearance to the eggs. Mr. Charles Girard, who assisted me in their examinations, suggests that these globules might be the cells in which spermatozoa will be developed, a suggestion to which I should be inclined to assent, if I did not find among

the notes I made in examining a large number of those animals in 1847, that I had found in some specimens spermatozoa in the general cavity of the body instead of eggs.

3. *Sipunculus corallicolus* (Pourt.)—A small species, not more than two or three inches long, of a pale pink color, with darker extremities. The trunk is covered with very small black dots, which seem to be hard, round bodies, with a translucid center. Similar ones are found at the posterior extremity of the body. The retractor muscles are attached about the middle of the body. Inhabits the dead stems of corals, in which it has, probably, some means of boring, as the cavity it inhabits has exactly the shape and size of the body. Found near Cape Florida, in Key Biscayne Bay.

4. *Sipunculus granulatus* (Pourt).—A species a little larger than the preceding, of a gray color, with black, irregular patches on the dorsal side; ventral side lighter. The skin resembles shagreen, being covered with smooth, rounded granules. The retractor muscles are attached very near the posterior end of the body. This may, however, only appear so from the great contraction of the only specimen in my possession. Found in Key Biscayne Bay, Florida.

Genus PHASCOLOSOMA—*Leuck.*

Represented on our shores by a species very closely allied to, if not the same as *Sipunculus Bernhardus* of Forbes. I am not prepared to distinguish it from the latter, and accordingly record it here under that specific appellation.

5. *Phascolosoma Bernhardus.*—It was dredged by Mr. Desor in the neighborhood of Nantucket, and found by Mr. William Stimpson in the stomach of a haddock caught off Cape Ann. To his kindness I owe some dried up specimens, and also one preserved in alcohol. The internal organs I failed to examine, but I could still trace the retractor muscles to the posterior extremity of the body. The skin appears to be covered with small black dots at the posterior extremity, which when magnified appear to be solid pieces in the shape of a horseshoe, sticking out of the skin. They probably serve to the animal for holding himself on the shell which he inhabits. The shells inhabited are usually *Buccinum ciliatum* and *Fusus harpularius.*

Thus three species only of Gephyreans are known to inhabit New England, and two at Cape Florida. This is the whole number known on the American coast of the Atlantic. There remains a new and rich harvest for naturalists: for if we compare that number with the eight

English species enumerated by Ed. Forbes, and bearing in mind the extent of our coast, we surely have a right to predict the discovery of many more.

4. On the Limit of Perceptibility of a Direct and Reflected Sound. By Prof. Jos. Henry.

Prof. Henry stated, that, at the meeting of the Association at Cambridge, he had made a communication relative to the application of the principles of acoustics to the construction of rooms intended for public speaking. In that communication he had stated, as an important proposition, that when two portions of the same sonorous wave reach the ear of an auditor,—one directly from the origin of the sound, and the other indirectly,—after one or more reflections, if the two do not differ in the paths they travel by a difference greater than a given quantity, the two sounds will enforce each other, and one louder sound will be perceived. If, however, the interval is greater than a certain limit, the two sounds will appear distinct, or an echo will be perceived.

As an illustration, suppose a speaker to stand before a wall at the distance of say ten feet: in this case the audience in front would hear but one sound. The direct and the reflected impulse meet the ear within the limit which I have called the limit of perceptibility. This limit,—a knowledge of which is of considerable practical importance,—may either be expressed in time, or in space. The simplest method of obtaining its amount is that of clapping the hands, while standing before a perpendicular wall: if the distance of the observer be sufficient, an echo will be heard. If, in this case, the observer gradually approach the wall, and continue to make the sound at a definite point, the echo will cease to be perceived, and the two sounds will appear as one. If the distance from the wall be now measured, twice the distance found will give the limit of perceptibility in space. If the same quantity be divided into the space through which the wave of sound is known to travel in a second, we shall have the limit of perceptibility in time.

The foregoing plan is the most simple, but not the most accurate method of arriving at the quantity sought. The better plan is to employ another person to produce the sound, while the observer is stationary at the distance—at least 150 feet from the wall. The person who produces the sound being placed between the observer and the wall, at such a distance from the latter as to give a distinct echo, he is then directed gradually to approach the wall until the echo and the

direct sound become one. The distance measured, as before mentioned, will give the limit required.

From a series of experiments on this plan, Professor Henry found the limit of perceptibility to vary from about 60 to 80 feet, or, in other words, the distance from the wall at which the echo ceased was from 30 to 40 feet. This will give from the 1-20 to the 1-15 part of a second, in time, for the ear to distinguish the difference of two sounds which follow each other at an interval of 1-15 of a second.

The experiments, when made under the same circumstances, gave the same result, almost within a single foot; but when a different source of sound was employed, and different observers, there was observed a difference of results, giving the limits between 1-20 and 1-15 of a second. The limit was less, with a sound produced by an instrument which gave a sudden crack, without perceivable prolongation, such as is produced by an ordinary watchman's rattle, when made to emit a single crack. This difference may be explained by taking into consideration the actual length of the sonorous wave. If a sound occupies $\frac{1}{4}$ of a second, which is about the time required for the utterance of a short, single syllable, the length of the sonorous wave will be about 300 feet, and hence, when the distance traveled by the two sounds is not more than 80 feet to and from the wall, the two waves must overlap through a considerable portion of their whole length, and will be only separated at the two extremities. The portion of overlapping may, therefore, determine the limit of perceptibility, and this, again, is combined with the fact of the continuance of a sonorous impression on the nerve of the ear.

5. Current Chart of New York Bay, from Observations in the Coast Survey. By Prof. A. D. Bache, Superintendent.

At the meeting of the Association in New Haven, I presented a Current Chart of Boston Harbor, from observations by Lieutenant Commanding Maffitt, U. S. N., Assistant in the Coast Survey, upon a plan devised by me for representing the direction and velocity of the currents at the surface. The Chart now submitted to the Association exhibits the results of observations made in New York Bay, by Lieutenant Commanding Charles H. Davis, U. S. N., Assistant in the Coast Survey, and is upon the same plan with the former Chart.

The Chart of Boston Harbor illustrated the effect of obstacles at and below the surface, as islands, rocks, etc., in deflecting the current, and modifying its rate. This one shows the influence of a great Bay,

and of obstacles below the surface, consisting of shoals of various magnitudes, and different degrees of elevation above the general surface of the bottom. The Chart shows the direction and velocity of the water at the flood.

The parallel lines indicate the directions of the currents, and the distances between them are in the inverse proportion of the velocities. As the Chart is from observations at a limited number of stations, the extent of particular directions and velocities is not rigidly defined. The eye seizes rapidly the generalizations of the facts, and with a certainty which no tabular view of the results would enable the mind to grasp.

The scale of the Chart now shown is such, that a velocity of half a mile per hour is represented by a distance of half an inch between the parallels, and greater velocities by proportionately less distances.

The water from the ocean sets into New York Bay in a direction nearly perpendicular to a line from Rockaway entrance to Sandy Hook, and at the rate, on the average, of about one mile per hour. The water has Raritan Bay to fill, tending to turn the current in a westwardly direction, and New York Inner Bay, or Harbor, tending to turn part of the current to the north. These are modified, but in an inconsiderable degree, by the shoals, between which are the channels for entering the Bay; the inconsiderable area of the section at the Narrows compared with that across the entrance of the first-named locality, tending, also, to give a controlling action to Raritan. The greatest velocity in the Outer Bay is in Gedney's Channel, (discovered in the progress of the survey,) being about two miles per hour. The various directions of the currents met with in passing through either of the outer channels into the main ship channel, and thence up through the Narrows, are very plainly seen from the Chart, and the tendencies toward different shoals and through different channels. The preference which is given to the Swash Channel, for vessels of moderate draft, is seen to result, not only from the shorter distance, as compared with the main ship channel, but from the directions of the currents setting through it until its upper end is nearly reached. The eddy currents to be avoided are distinctly shown. The improvements which the study of this Chart suggests in the number and localities of observation are even more striking than in the case of Boston Harbor, where the current observations had been, relatively, much more numerous than in New York Bay.

Prof. PEIRCE observed that the study of such charts must be useful guides in the improvement of harbors. He found that the maximum

velocity of ebb would determine the position of the deposits of bars. He observed how important such investigations were to the harbors of the Lakes, as well as those of the Atlantic coast.

Prof. BACHE stated, that the charts on this plan should be made for the ebb as well as flood, and for intermediate divisions, as quarters of the tide, for which the Coast Survey observations afforded materials; and (in reply to a question from Prof. Mitchel) that these charts had originated in a want, felt in the Coast Survey, in representing the observations of currents which had been elaborately made in the progress of the work.

Capt. WILKES inquired whether, in the progress of the observations at Charleston harbor, referred to, yesterday, in the Association, the action had been observed during flood as well as ebb tide, and at intervals.

Prof. Bache stated that the observations to which he had referred, yesterday, comprised those at different times of tide, and in various localities on the shoals, and in the channels. They are still in progress.

Mr. REDFIELD observed that the deposits at the entrance to our bays, undoubtedly came from the shores, and were probably carried by the action of the waves and tides to their places, and probably, as supposed by Lieut. Davis, by the flood tide. The particles being more or less finely divided, and assuming a position accordingly; the very fine particles being carried to sea by the ebb tide, and deposited as ooze, or mud.

Prof. PEIRCE remarked upon the importance of the charts presented, and the complete view which they gave of the facts intended to be represented—worth every thing to the navigator in his art, and to the engineer in his generalizations.

Prof. SCHAEFFER observed, that, in a survey of the entrance of the Harlem river, near New York, made by him some years since, he had observed facts in regard to deposits at the entrance, which he had been unable to explain, until he became acquainted with the theory of Lieut. Davis in regard to the action of the flood tide.

6. ON THE POST-PERMIAN DATE OF THE RED SANDSTONE ROCKS OF NEW JERSEY AND THE CONNECTICUT VALLEY, AS SHOWN BY THEIR FOSSIL REMAINS. By WM. C. REDFIELD, Esq., of New York.

Mr. REDFIELD adverted to a communication of Dr. C. T. Jackson, in the proceedings of the Boston Natural History Society, in which he maintained that the lower portion of the sandstone of the Connecticut valley, as well as that of Nova Scotia, might belong to the Silurian epoch. He also alluded to a communication of Mr. D. A. Wells on the

same subject, in which he represented the upper and lower portions of the series as being unconformable. This Mr. R. regarded as a local phenomenon; that for the most part they presented an unbroken succession of conformable strata, characterized by a flora and a fauna as recent as the Trias.

Prof. Agassiz recognized the specimens of the flora as belonging to the era of the New Red sandstone series.

Mr. Foster remarked, that from the investigations of the Messrs. Rogers and others, it was indisputable that the metamorphism of the rocks of the Appalachian chain, took place at the close of the Carboniferous era; but that the sandstone of the Connecticut valley had not partaken of that metamorphism. It was also highly probable that the sandstone was older than the coal deposits of Richmond, which were proved to belong to the Oolite. Therefore, whatever might be the ultimate position assigned to this sandstone, it was intermediate between these two epochs. It was found, too, as a general rule, that whenever a great change occurred in the physical conditions of the earth, those changes were indicated by the character of the deposits. Thus, the base of many of the great systems of rocks is occupied by conglomerates, succeeded by coarse sandstone grits; and it was not until after the lapse of a considerable time, that the finer silts were thrown down. It was also found that these coarse grits and conglomerates were barren of types of organic life; whereas the finer silts contained the most abundant traces. The fact, therefore, that the sandstone at the base of this series of rocks was unproductive in fossils, while the shales contained numerous traces of their existence, did not necessarily imply that the rocks belonged to two epochs of deposition.

As to the unconformability of the two portions, as described by Mr. Wells, he remarked, that this sandstone, throughout its range, exhibited numerous instances of the intrusion of trappean rocks. These took place at successive intervals, as was evidenced by the manner in which they were intercalated with the sandstones. These belts, like those of Lake Superior, were not the result of protrusion between the strata, but of overflows, like submarine volcanoes, and mingling with the sediments there being accumulated. There might, therefore, be an unconformability between the upper and lower portions of the series, without the necessity of presupposing a great lapse of time, unless that unconformability was found to prevail over an extended area.

A communication from the Directors of the Young Men's Mercantile

Library Association, inviting members of the American Association to visittheir Library and News Room, was received, and the invitation accepted.

SECOND DAY, TUESDAY, MAY 6, 1851.

(Afternoon Session.)

THE Association met at 3 P. M.—Prof. BACHE in the Chair.

Dr. YANDELL was elected an additional member of the Standing Committee.

The PRESIDENT communicated the request of the Standing Committee, that persons having specimens of Natural History, and other objects of interest, to exhibit, would please hand in their names; and stated that the names of several gentlemen had already been placed on the programme of to-morrow for this purpose.

Dr. J. P. KIRTLAND was then called to the Chair, and the following papers presented:

1. ON THE STRUCTURE AND REPRODUCTION OF PORITES. By Prof. L. AGASSIZ.

[*Not received.*]

2. ON THE EXISTENCE OF PHOSPHORUS IN THE CARBONATES OF IRON OF THE DES MOINES COAL FIELDS. By Dr. D. D. OWEN.

THOSE who have given their attention to the analysis of minerals, are aware of the difficulties to be encountered in demonstrating the presence of minute quantities of phosphorus in ores of a complex character; especially in the presence of alumina, iron and magnesia. The ordinary methods of detecting phosphoric acid in simple acid solutions, are quite inappropriate for such combinations, since the first step in the process—the neutralization by ammonia—at once embarrasses the subsequent process by enveloping the phosphate in a bulky precipitate of alumina and iron, even before the free acid is entirely neutralized, which disguises its characteristics, and impedes its subsequent reactions.

The ores to which particular reference is made in this paper, are essentially carbonates of the protoxide of iron, containing variable

quantities of silica, alumina, magnesia, lime, and alkalies; together with a considerable per centage of bituminous or coaly matter, analogous in their composition to the so-called "Mushet Black Band," or "Carboniferous iron stones" of Scotland, which occur at Crossbasket, Calder, Old Monkland; the Cairnhill ore, near the Ell coal; and the Airdrie ore, under the crop of the Glasgow splint, or fifth seam of coal.

The presence of phosphorus in the Des Moines ores, was indicated by the application of the molybdate of ammonia to the nitric acid solution of the ore, when a yellowish white precipitate appeared floating on the surface of the liquid.

This indication was subsequently confirmed, by following a new process recommended by Fresenius for the separation of phosphorus from iron—viz: by reducing the nitro muriatic solution by sulphate of soda; nearly neutralizing the free acid by carbonate of soda; adding a few drops of chlorine water, and then an excess of acetate of soda; when a considerable white floculent precipitate of perphosphate of iron fell. By boiling this solution until the precipitate fully settled, adding chlorine water until the fluid became distinctly red, the perphosphate of iron, along with some basic peracetate of iron, was thus separated. After collecting the precipitate on a filter, and washing it thoroughly with hot water, the phosphoric acid was separated by the following process: The precipitate containing the phosphate of iron was reduced with the sulphite of soda, the excess of free acid being neutralized by carbonate of soda. Caustic soda was then added, and the whole boiled until the precipitate became black. Thus the whole of the iron was precipitated, while the phosphoric acid remained in solution, combined with the alkali. The filtrate, after being rendered acid by hydrochloric acid, was neutralized by ammonia. A very small precipitate of alumina fell, which had been precipitated with the perphosphate of iron. This was first separated by filtration; then the sulphate of magnesia, to which chloride of ammonia was previously added, was finally poured into the filtrate (thus freed from all iron and the trace of alumina,) when a white granular precipitate of ammonio-phosphate of magnesia, fell.

Proceeding by this method, the quantity of phosphorus in these Des Moines iron stones can be estimated on a delicate balance, of Œrthage construction, even operating on a single centigramme.

One and a half per cent. of phosphorus was obtained from a black band of carbonate of the protoxide of iron of a few inches in thickness, found intercalated in the middle shaly divisions of the coal measures

of the Des Moines, above Bennington. Another, from near Dam 26, below Lafayette, yielded six-tenths of a per cent. of phosphorus.

The first of these ores contains microscopic Lingulas. May not the source of phosphorus in these ores be attributed to these brachiopodæ?

The existence of phosphorus is not only a matter of scientific interest, but also of practical importance, since Mr. Collier and Mr. Rinman attribute the cold-short property of iron, to the presence of phosphate of iron; though Mushet, who probably knows as much about iron as any other man, doubts the fact; "for," he says, "it has always been noticed that the most perfect qualities of iron, particularly the Swedish, gave out in working a very strong phosphoric smell." Moreover, he asserts that any iron can be made cold-short—i. e., brittle when cold—by introducing silica in excess into the blast furnace, through the medium of the flux or otherwise.

In support of this view, he remarks, in his work on iron and steel, "The flue cinder of the valley furnace, which, on an average, contains 30 per cent. of silica, and the flue furnace cinder of the pudding furnace, containing 40 per cent., while sand bottoms were in use, furnished striking illustrations of this fact. At first, when these cinders, containing from forty to fifty-two per cent. of iron, were returned to be smelted for the production of forge pigs, the brittleness of the iron was so much increased, that fears were entertained as to the practicability of their use, and maintaining a marketable quality of iron. The change of system which took place from puddling on sand to puddling on iron hearths, by introducing a less quantity of silica into the blast furnace, had a great tendency to reduce this evil, and restore fiber to the iron." And he concludes by saying: "from this fact being so clearly ascertained, we obtain a clue to explain the probable cause of cold-short properties in iron generally, by attributing it to a predominant quantity of silica in the ore, rather than to the existence of phosphorus."

As this opinion, from so experienced a man as Mushet, is at variance to the statement of Binneau, made to the meeting of the British Association, held at Birmingham in the summer of 1849, in which that gentleman remarks, that phosphorus has been discovered in Swedish iron, whenever it presented the peculiarity of what is termed "cold-short," I would therefore call the attention of chemists and iron manufacturers in this country to the subject.

It seems that it is only by repeated careful chemical analysis, according to the most approved methods of detecting and estimating

phosphorus, that differences of opinion among scientific men on this important subject, can be reconciled. Should that element invariably be found in cold-short iron, while it should be proved to be uniformly absent, or in exceedingly minute portions, in iron having the opposite qualities, then it is a fair inference that phosphorus imparts this quality.

As none of these Des Moines ironstones have yet been worked, we can not as yet draw conclusions on the subject from that source.

In conclusion I would remark that the improved methods introduced for the analysis of complex phosphatic compounds, will probably show the existence of phosphorus in ores and minerals, where the old methods failed to discover it.

3. On a Method for Distinguishing between Biaxial and Uniaxial Crystals when in thin Plates; and the Results of the Examination of several supposed Uniaxial Micas. By Wm. P. Blake.

The greater number of the "black micas," so called, have a deep olive-green or "bottle-green" color, so deep as generally to be opaque, when the thickness exceeds one-fourth of a millimetre;* the other colors most frequently observed are a dull brownish green, sometimes yellowish, and a fiery red. Of course their power of absorbing light varies greatly; thus, the mica from

Greenwood Furnace, Orange County, N. Y., is opaque in	plates	over	.500	mm.	thick.
Sussex Co., N. J., (No. 115,) bottle-green,	"	"	"	.222	"
St. Lawrence Co., N. Y., (No. 116,) brownish green,	"	"	.062	"	
Loc———? (No. 113,) olive-green,	"	"	.042	"	

These thicknesses were taken with the instrument called the "Sphéromètre," designed by M. Cauchoix, and constructed by Soleil.†

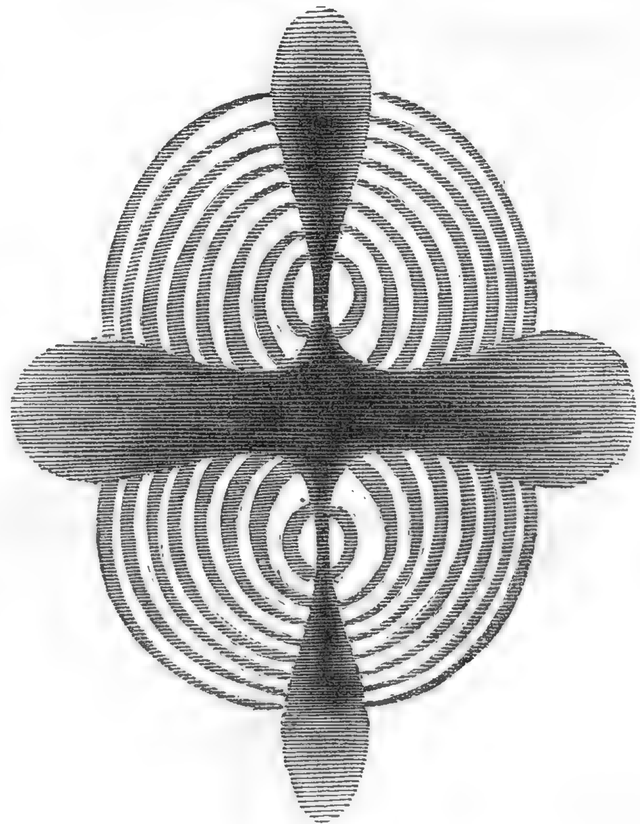
In stating the color of specimens, I have given that color which they present when a plate sufficiently thin to be transparent, is held near the eye, while the light from the clouds or window is allowed to pass through it. It is not, therefore, possible to examine plates of these micas in the polariscope, in the ordinary way, even where their thicknesses are less than those stated above; and of course, in such thicknesses, the images formed around the pole or poles of the resultant axes, are much extended, and it would generally be impossible to distinguish them, or the dark bars which cross the center; and when

* Ordinary visiting cards are from .3 to .4 of 1 mm. thick.

† Described by Péclet, Traité de Physique, Paris, 1847; 4e. edit., t. I., p. 5.

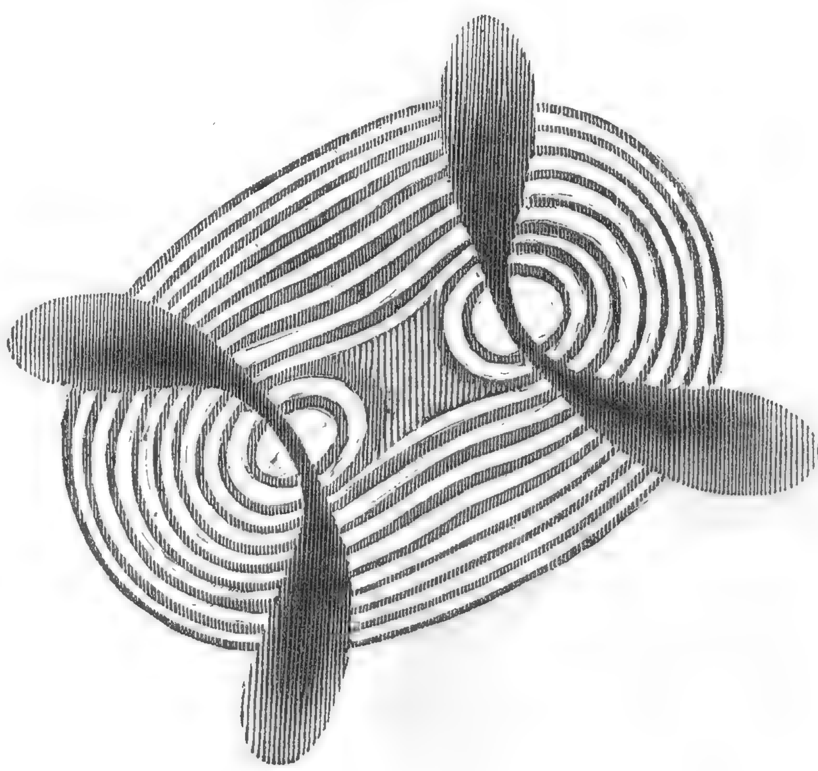
they can be seen, they so nearly resemble the symmetrical image formed in uniaxial crystals, that they can not be distinguished from them.

Fig. 1.



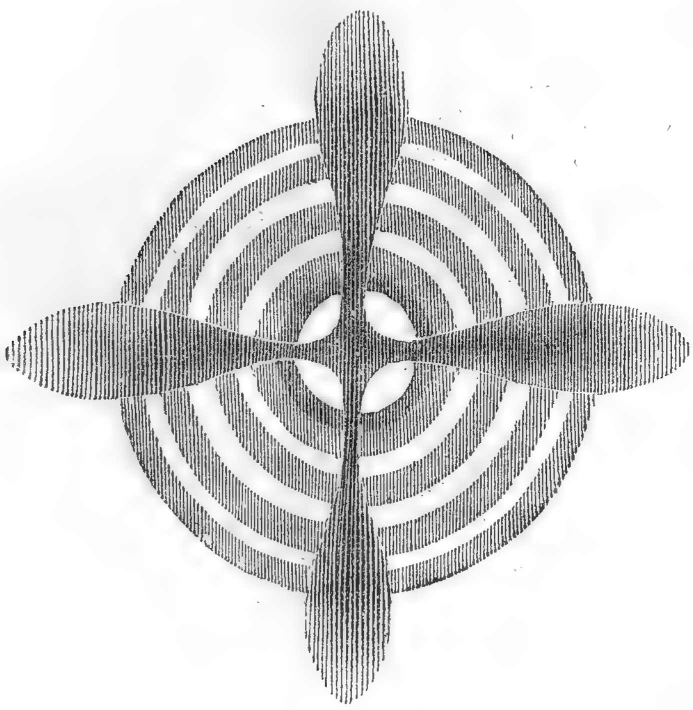
In order to enable me to give these dark micas a more complete and thorough examination, I have arranged, in addition to the combination of lenses and Nichols' prism, which I described at the meeting of the American Association last August, a large convex lens, placed between the polarizing mirror of my instrument, and the film of mineral to be examined. I also use, instead of the variable and uncertain light from the clouds, a broad gas flame, which I bring near to the mirror, so that its reflected image is condensed by the large convex lens upon the mica; with this arrangement I have been able to discern the *rings* and *cross* in plates of the dark micas, much thicker than could be examined by any former arrangement. It then became interesting to examine some of the micas whose optical uniaxial character was equivocal, and for this purpose I adopted the following test: It is well known that when a plate of Iceland spar, cut with faces perpendicular to the axis, is placed in a polariscope, (the eye piece being "crossed,") and then rotated in its own plane, the symmetrical cross and rings do not suffer any change of form or position; if, however, a plate of a biaxial crystal—as niter—be rotated in a similar manner, the dark bars which form the cross as in Fig. 1, will, when the plate has been rotated 45° "open out," and take the form and position represented in Fig. 2.

Fig. 2.



These facts and figures, though familiar to the student of optics, I here repeat for the sake of the explanations which follow; and this is particularly important, since observers of eminence have evidently mistaken the optical character of many of the so-called *uniaxial* or *hexagonal* micas.

FIG. 3.



When the micas referred to are examined with my instrument, I find similar evidence of a *biaxial* character.

The thin plates of these micas, if the line joining the poles of the axes be parallel to the plane of primitive polarization, give to the eye symmetrical crosses and rings, as in Fig. 3; that is, so *nearly symmetrical*, that it is hardly possible to distinguish any variation from symmetry, and such crosses might be taken as proof of a uniaxial character. But on rotating 45°, as in the case of the niter crystal, we lose the symmetrical form of the cross, which opens out, as represented in Fig. 4. This deportment of the cross may be observed, when, owing to the depth of color, it is not possible to discern the rings clearly.

FIG. 4.

A method given by Müller,* also depends upon this deportment of the dark bars; it consists in rotating the plate of mica when on the table of M. Noremberg's apparatus, (the ray being extinguished by the eye piece;) if the mica be biaxial, the light is alternately for every 45° of the rotation, transmitted, or shut off; if *uniaxial*, no change is perceived. By this method the image of the cross and rings is so much extended, and dimly defined, that the outlines can not be

* Lehrbuch der Physik und Meteorologie. Braunschweig, 1844, p. 588.

traced by the eye, and a slight opening out of the cross is not so readily noticed, even by a change in the intensity of the light, as when its image is contracted and sharpened in outline, by the action of lenses.

In the following table are given the localities and colors of several micas hitherto generally considered uniaxial, but which, on examination with my arrangement, have given evidence of being optically *biaxial*.

76. Greenwood Furnace, Orange Co., N. Y.; olive-green; rhombic plates.
77. Greenwood Furnace, Orange Co., N. Y.; olive-green; (second specimen.)
79. Greenwood Furnace, Orange Co., N. Y.; olive green; (third specimen.)
86. Easton, Pa.; a white silvery mica.
88. Topsham, Maine; fine crimson red.
89. Mount Vesuvius; dark green.
101. Mount Vesuvius; dark green; another specimen, and is clearly biaxial.
105. Mount Vesuvius; dark green; a thicker plate of specimen 101—clearly biaxial.
102. Mount Vesuvius; clear, with a delicate shade of green; banded with bands of a deep green, meeting at angles of 60°.
103. Mount Vesuvius; from same specimen as 102, but is thicker.
104. Mount Vesuvius; from same specimen; still thicker, gives a fine elliptical image.
111. Franklin Furnace, Sussex Co., N. J.; deep copper red; from G. J. Brush, to B. Silliman, Jr.
109. St. Jerome, Canada; coppery, reddish; angle estimated at 10°.
114. Moor's Slide, Ottawa, Canada; dark bottle-green; T. S. Hunt to B. Silliman, Jr.
116. St. Lawrence Co., N. Y.; dark brownish green; opaque when over .062 mm. thick.
84. Hammond, St. Lawrence Co., N. Y.; rich smoky yellow, from Saml. W. Johnson.
68. Hammond, St. Lawrence Co., N. Y.; dark brownish red; (*black* by reflected light.)
106. Gouverneur, N. Y.; (bowlder;) dark brown.
81. Monroe, Orange Co., N. Y.; dark green.
108. Monroe, Orange Co, N. Y; dark bottle-green; from S. R. Horton to B. Silliman, Jr.
107. Locality ——— ? from Cambridge Cabinet; rich brown; is in beautiful rhombic plates.
112. Locality ——— ? from Cambridge Cabinet; deep green; is like the Greenwood Furnace Mica.
63. Moriah, Essex Co., N. Y.; fiery red; Lederer Cabinet; angle measurable.
139. Warwick, Pa.; olive-green; (brownish;) angle estimated over 10°; this mica much resembles the Vesuvius specimens, Nos. 102 and 103.

With the exception of the dark micas mentioned in the following table, I have not examined any that do not give evidence of being optically *bi*axial; and it is probable that these exceptions would give the modifications of the cross, etc., if their dark color did not render it impossible to observe them in plates sufficiently thick. But if

biaxial, the angle for the Sussex, New Jersey, mica, No. 115, must be very small.

98. Locality ———? dark olive-green; resembles No. 81.
83. Locality ———? Yale College Cabinet; color intensely green.
115. Sussex Co., N. J.; dark green; opaque when in plates over .222 of 1 mm. thick.
113. Locality ———? N. Y. Lyceum of Natural History; opaque in plates over .042 mm. thick.
148. Middletown, Ct.; very dark green.
146. New York Island; very dark olive-green; in granite veins traversing gneiss.
147. " " " " " " "

To Prof. B. Silliman, Jr., I am indebted for the free use of his specimens for these investigations; the biaxial character of many of them was suspected by him, when they were first examined, as is mentioned in his communication to the Am. Jour. Science, Vol. X., Nov., 1850.

In specimens of mica referable to the species Phlogopite, having the inclination of the "resultant axes" between 5° and 20°, when the thickness is so much reduced that the systems of rings around the poles are not distinctly separated, the angular inclination of the axes can not be determined in the ordinary manner. Further observations upon this point I reserve for a future communication.

4. On the "Superficial Deposits" of the North-Western Part of the United States. By Col. Chas. Whittlesey, of the U. S. Geological Survey.

Mr. W. commenced by stating, that, as yet, the loose materials,—the sand, gravel, clay, and bowlders,—that are spread over the indurated rocks of the west, and north-west, have received no scientific name.

They will, at present, be called by the common appellation of "drift," or superficial deposits, as it is not certain that they belong to any of the recognized members of the tertiary strata, and differ from the "quaternary" of Europe.

The sections presented to the meeting were numerous, showing the extent and order of superposition in these deposits, in Ohio, Michigan, Illinois, and Minesota. There was one from the Canada shore of Lake Erie, southerly through Cleveland, to the summit land, near Akron, Ohio.

2. From Detroit, westward, to the summit between the lakes Erie and Michigan.

3. From Chicago, on Lake Michigan, west, to the summit between Lake Michigan and the Mississippi.

4. From Sheboygan, on Lake Michigan, west to Lake Winnebago.

5. A sheet of detailed sections, showing the interchangeability and contemporaneous character of the *red* and the *blue* clays, at *Racine, Milwaukie,* and *Sault St. Marie.*

6. A section from La Pointe, Lake Superior, to the Apuknoyekan river.

7. From the west end of Lake Superior, up the valley of St. Louis river, across the Mesabi range to the Grande Fourche of Rainy Lake river.

The explanation of these sections went to show, that in all parts of the north-western States, east of the Mississippi, the same *order of succession* or stratification takes place.

In the lower ports, such as the basins of the great Lakes, Erie, Huron, Michigan, and Superior, at and near the level of the waters, and also in the valleys of the principal rivers at the lower parts, are found the fine, laminated, marly clays. Around the western half of Lake Erie and the southern part of Lake Michigan, they are *blue.* Passing down the west coast of Lake Michigan, at Racine and Milwaukee, the blue becomes purple, and the purple, red. At Sheboygan, it is entirely red; and the section, from thence to Lake Winnebago, showed it to be very largely developed, rising to a hight of four hundred feet above Lake Michigan. On the northern shores of Lakes Michigan and Huron, it is largely deposited, and the local section at Fort Brady, Sault St. Marie, showed the same to be there over one hundred feet thick.

Passing thence to the westward, along the lake, it is seen rising four and five hundred feet above the water on the Ontonagon river, the Montreal river, and the St. Louis river.

Mr. W.'s section, from La Pointe to Apuknoyekan river, exhibited this bed of red, marly clay, overlaid by coarse sand-gravel, and, at the hight of two to five hundred feet, composed, in places, of terraces of large, water-worn bowlders of northern, igneous rocks.

The section from Fond du Lac, of Lake Superior, to the Grand Fork of Rainy Lake river, exhibited the drift over a line of about two hundred miles, in a north-west direction, from the basin of Lake Superior to the basin of the lakes and rivers that discharge into Hudson's Bay.

Passing up the valley of the St. Louis river, over the Grand Portage, the red clay rises to the hight of four hundred feet, and beyond that is overlaid, as usual, by coarse materials. Near the mouth of the Savannah river it graduates into a purple, laminated clay, and, pro-

ceeding up the St. Louis, it becomes of an ash color, with reddish and purple patches. It embraces fragments, and half-worn pebbles, of a Silurian limestone, as well as of igneous rocks. About the Eshquagendy Lakes, and on the Embarras river, (a fork of the St. Louis,) the coarse, sandy materials, embracing buried timber, occupy the surface. Here we cross the Mesabi range of mountains; by estimate, eleven hundred feet above Lake Superior, or say, seventeen hundred feet above the Ocean. The rocks are granite, sienite, gneiss, mica slate, and the like. Around the sharp knobs of the Mesabi range are immense piles of rounded boulders, almost without earth or gravel, three or four hundred feet thick, composed of the adjacent rocks, rising nearly to the summit of the range. On the west and north-west, in the valley of Rainy Lake river and its southern tributaries, the Grande and Petite Fourches, at the level of the immediate valley composing the banks of those streams, is, every where, the ash-colored clay of the St. Louis repeated. And, at the sources of the Grande Fourche and the Mississippi, the ash-colored bed, containing fragments of a Silurian limestone, which Dr. Owen found in place on Lake Winnipeg, in Canada, is seen, overlaid by coarse sand, gravel, and drift ridges. For several hundred miles down the Mississippi the same deposits are visible.

The sections exhibited by Colonel W. of the Ohio, Michigan and Wisconsin superficial deposits, presented the same phenomena of the highest summits composed of coarse gravel, sand, and water-transported bowlders of northern and igneous rocks, mingled with bowlders and gravel of the subjacent rocks. In Ohio, of the granite, sienite, gneiss, trap, and metamorphic rocks of Lake Superior, mingled with the sedimentary slates, sandstones, iron stones, and limestones of Ohio. In Michigan and Illinois, the same thing happens; only the pebbles of lime rock predominate.

In Wisconsin, the most remarkable accumulation of limestone pebbles and boulders, in masses, may be seen between Sheboygan and Fond du Lac of Lake Winnebago, being a series of peaks and hollows, from twenty to one hundred feet deep; very steep at the sides, without water; and constituting an elevated ridge of more than fifty miles in length, in places three hundred feet above Lake Michigan. It is known in the region as the "Potash Kettle" country. The surface of the red clay, and of the superior limestone gravel masses, is covered with bowlders of igneous rocks, so numerous that it is often necessary to cart them off before the soil can be tilled; but *beneath* the surface they

are very few. It is so in northern Ohio. The surface bowlders are far more numerous, and of a different composition than those in the drift. Mr. W. presented specimens of buried wood, taken from the blue and red marly clays, at various and distant places; one from Cleveland, in the blue marl, twenty feet below the surface, and another from Dover, in Cuyahoga county, another from the hills east of the Scioto river, near Chillicothe, Ohio, about one hundred feet above the water level, and thirty feet deep in the clay: one from the red clay at Appleton, on the Fox river, Wisconsin, one hundred and fifty feet above Lake Michigan, and eighteen feet deep, and one from the same clay at Green Bay, fifty feet below the surface of the lake. Mr. Lesquereux, a distinguished botanist, from Switzerland, now in Ohio, pronounces them to be red cedar. Some vegetable mold, taken from the clay at Cleveland, was found by this naturalist to contain leaves of the spruce-pine and cranberry.

Col. Whittlesey presented several packages of shells, collected by himself, at Cleveland, at Peoria, (Illinois,) New Harmony, (Indiana,) St. Louis, (Missouri,) and Dubuque, in Iowa, from the superficial deposits. He had hoped to meet conchologists, here, who would classify these shells, and from that classification that the age and geological position of the deposits might be determined. He anticipated, from their *general* resemblance to the shells of the loes of the Rhine, in Germany, that our drift is contemporaneous with it; but Professor Agassiz, and others, after a hasty examination, find new and different species, and they find little unity of *species* among the collection itself. They are mostly land shells, and all *fresh water*, and Mr. Lesquereux is positive that all the timber has met with fresh water, only. This separates the western drift from the tertiary clays of Lake Champlain, and the marine drift of the St. Lawrence; and, whatever may be the age and geological equivalents of the western drift, it is, apparently, *one* system, and may be studied as independent of eastern classification.

Mr. W. felt himself justified in calling all this vast, wide-spread, superficial mass, extending from the interior of Ohio to the plains of the Red River of the north, and the Saskatchawan, *one formation*, with members; and that its differences of composition,—its clays, marls, hard pans, gravel, bowlder masses, and sand ridges,—are due to modifications of that force, whatever it was, which brought on the materials, and, in so doing, scratched, polished, and abraded the surface of the underlying indurated rocks.

A discussion took place on the reading of this paper, in which Messrs. AGASSIZ, FOSTER, MATHER, EVANS, ANTHONY, and others, participated.

Mr. ANTHONY inquired if any new forms of shells have been recently discovered in the deposit at New Harmony, and stated that he had examined with great care all the shells he had been able to procure from that deposit, and had been able to detect but a single species not now found living in that vicinity.

Prof. EVANS, of Chicago, Ill., remarked, that in reply to Mr. Foster's query in reference to the remains of the mastodon in the region described by Mr. Whittlesey, and his proposition that these remains were found only in the substrata, showing that the mastodon became extinct before the advent of man on the face of the earth; he would state that about forty miles west of Chicago, in grading for the Aurora branch railroad, a tusk of very large size, measuring about eight feet in length, and about eight inches in diameter, had been found near the surface of the alluvial formation, in a boggy swale, near a salt lick. Whether there was a possibility of this specimen having been detached from a substratum, and subsequently lodged in the place where found, Prof. E. was unable to say. As there were few if any other portions of the skeleton found in that place, he would not say that this might not be the case; yet, from the general proximity of such specimens to salt licks, and the existence of this proximity here, he thought it highly improbable.

Major OWEN said, that he could bring forward one fact, from personal observation, which might throw some light on the subject. At the Blue Lick springs he had obtained some remains of the Mastodon, found close to the tusk, nine feet long, which had been sent to Peale's Museum, in Philadelphia. He had searched diligently in the black bog earth, in which the animals had evidently been swamped, while crowding to the brine springs (from which, up to the present day, salt can be made,) but had found no shells to characterize the epoch. Fourteen miles, however, from that place, while searching for gigantic mammalian remains in yellow clay, (from the abrupt bank of which, after heavy rains, bones were frequently seen to project,) he found no bones, but found an Ambonychia, imbedded fifteen or twenty feet below the surface. This, on examination, seemed to be identical in species with the *Ambonychia amygdalina*, described by Prof. Hall, in his "Palaeontology of New York." It had consequently been derived from the

adjoining blue limestone or Silurian formation, either by agencies which had detached it from the limestone and carried it to the clay, or by having the loam of the drift, or a yet later period, wash down upon the mammalian remains, bringing with it the debris and fossils of the surrounding Silurian rocks. From the same locality he obtained, a few weeks afterward, a grinder of the *Elephas primigenius*, or mammoth.

In other localities, where no such disturbance had taken place, the imbedded shells, accompanying similar remains, had been pronounced by Lyell, on his late visit to the United States, as showing the loam bluffs of the West and South to be *contemporaneous with the drift;* whereas, in Canada and New York, some lacustrine and swamp deposits of marl and bog earth, including the bones of extinct quadrupeds, were decidedly *post-glacial*.

SECOND DAY: TUESDAY, MAY 6, 1851.

(*Evening Session.*)

The Association met at 8 P. M.—Prof. Bache in the Chair.

In consequence of the impracticability of procuring professional reporters, the Standing Committee requested that members would, themselves, prepare abstracts of all remarks made by them, in the discussion of papers, and hand them to the Permanent Secretary.

The following paper was then presented :

Parallelism of the Palæozoic Rocks of New York, with those of the Western States, and of all these with the Palæozoic Strata of Europe. By Prof. James Hall, of New York.

[*Not received.*]

THIRD DAY: WEDNESDAY, MAY 7, 1851.

(Morning Session.)

The Association met at $9\frac{1}{2}$ A. M.—the President in the Chair.

The minutes of the meeting of the Standing Committee were then presented.

On recommendation of the Standing Committee, it was determined that members making remarks be permitted to furnish abstracts of the same to the Permanent Secretary, during the day on which they are made; and that if not so presented, the Association receive a report of such remarks from persons appointed for the purpose.

The following gentlemen were then chosen as reporters for this day:

Mathematics—Prof. B. Peirce.
Physics and Astronomy—Prof. A. D. Bache.
Geology—D. H. Wells, Esq.
Zoology—Prof. L. Agassiz.

Prof. Bache stated that John H. Alexander, Esq., of Baltimore, had been appointed by the Navy Department a Commissioner to examine condensers as applied to marine engines, and requested that all persons who have it in their power to procure incrustations from steam boilers in the West, might forward specimens of the same to Mr. Alexander, by Adams & Co.'s Express.

An invitation to visit the Observatory having been received from the Director, Prof. Mitchel; Friday afternoon, after 5 P. M., was fixed upon for the purpose.

The following communication was received from the President of the Western Academy of Natural Sciences, and the invitation accepted:

Cincinnati, May 7, 1851.

To the Officers and Members of the American Association:

Gentlemen: The Members of the Western Academy of Natural Sciences have directed me to invite the members of your Association to visit the rooms of the Academy, in the building on the north-west corner of Fourth and Vine streets, for the purpose of examining their cabinet, which contains some rare fossils and shells, illustrating the Silurian formation of this region, and other formations of the Mississippi valley.

If convenient to the members, the rooms will be open on Thursday, after 1 o'clock, P. M., and until 6, P. M.

Very respectfully,

Your obedient servant,

GEO. GRAHAM,

President of the Western Academy of Natural Sciences.

An informal invitation to visit the Library and Reading Rooms of the Ohio Mechanics' Institute, was presented by the President, and accepted.

An invitation to visit and examine their Orograph, was received from Messrs. Fuller and Whetstone. This was accepted, the time to be fixed hereafter.

Dr. Yandell, of Louisville, was then called to the Chair, and the following papers presented:

1. ON THE SPECIAL HOMOLOGIES OF ACEPHALA. By Prof. L. AGASSIZ.

[*Not received.*]

2. ON A NEW METHOD OF GEOMETRICALLY CONSTRUCTING THE INTEGRATION OF QUADRATURES. By Rev. THOS. HILL, of Waltham, Mass.

THE spirit of this method consists in constructing the arc of curve from its radius of curvature, which represents its differential coefficient, provided the variable is represented by the angle which the radius makes with a fixed axis. The function to be integrated must be regarded as the arc of another curve, which is not, however, required to be actually drawn; but a substitute for it may be found in an isoperimetrical polygon, which may have as many sides as we please to give it. This polygon is to be taken as the involute of the required curve, which represents the integral; and this method is especially adapted to the integration of trigonometric functions.

Prof. PEIRCE remarked that Mr. Hill's method may be shown to have a simple and neat correspondence with the analytical method of quadratures adopted by the best geometers, and especially with those adopted in the discussion of the perturbations of the asteroids. It may also be made to illustrate some of the most recondite of the problems which occur in planetary perturbations, and especially in what relates to the equations of long period.

In reply to a remark by Prof. Bache, Prof. PEIRCE stated that the paper of Mr. Hill would be published in the Astronomical Journal, so far as it had reference to the science of Astronomy.

3. COMPARISON OF CURVES SHOWING THE HOURLY CHANGES OF MAGNETIC DECLINATION AT PHILADELPHIA, TORONTO, AND HOBARTON, FROM APRIL TO AUGUST, AND FROM OCTOBER TO FEBRUARY, AND FOR MARCH AND SEPTEMBER. By A. D. BACHE, LL. D.

THE diagram represents the curve of mean daily magnetic deviation, as derived from a series of observations made at Hobarton, Toronto, and Girard College, Philadelphia. The observations at the latter place, were printed by order of the Senate of the United States, under the general direction of the United States Topographical Bureau, and under my immediate supervision. Those for Hobarton and Toronto, were printed by order of the British Government, under direction of Lieut. Col. Edward Sabine. The tables of observations have been divided into two five-monthly periods; viz.: from October to February, (inclusive,) and from April to August, (inclusive,) according as the sun is north or south of the equator; March and September being taken separately, as in each month the sun is on both sides of the equator. Five divisions of the scale, correspond to one and one-eighth of a minute. The latitude and longitude of Girard College are 39° 58′ N., and 75° 11′ W.; of Hobarton, 42° 52′ S., and 147° 27′ E.; of Toronto, 43° N., and 79° W. Philadelphia and Toronto being situated at almost opposite portions of the globe, in latitude, from Hobarton, the curve for the latter place for October to February, corrresponds more nearly to the Philadelphia and Toronto curve for April to August, and vice versa. Hence they are compared together on the diagram. Besides, the north end of the magnet moving in opposite directions, at Hobarton and the other two places, during corresponding hours of local time, the two latter curves have been inverted, so as to compare the changes more minutely. The deviation at Hobarton is found to be much greater from October to February, than from April to August; while for March and September, it is intermediate between the two. The periods of greatest eastern or western elongation, are found also to occur much earlier from October to February, than from April to August, the first happening at 2^h., and the second at 3^h. These turning points invariably occur at earlier periods for Toronto and Philadelphia, than for Hobar-

ton. By comparing the three curves together, however, a very striking analogy is presented in their form. Those for Toronto and Philadelphia, have almost perfect coincidence throughout their extent, the seeming difference in the turning points, arising from the fact that the observations at the latter place were only taken every second hour. Thus the greatest western elongation of the Toronto curve is at 1h., whilst that for Philadelphia seems to be at 2h.; but observing their very close resemblance in general form, it is evident that the period of greatest elongation for Philadelphia, has occurred between 0^h and 2^h, during which interval no observation was taken. The Hobarton curve would likewise be almost coincident with the other two, but for the circumstance before mentioned, that its periods of greatest elongation are later.

Any theory which undertakes to explain the cause of the diurnal variation of the needle, must include as nearly coincident, the changes at Toronto and Philadelphia. The small differences between the changes as shown in the diagrams, are probably in part real, and in part due to the fact that the observations were made hourly at one observatory, and every two hours at the other. They should, however, enter as differences, to be explained in the minute application of a theory.

Captain Wilkes inquired, if the needles used had been compared with each other, and whether the small differences observed might not result from the different characters of the instruments.

Prof. Bache replied, that the observations being entirely for differences, unless they were used to detect rapid changes, as those which occur during an aurora, he did not conceive a comparison to be necessary. The magnetic bars used at the Girard College, were on Gauss' plan, and five pounds in weight; while those used at Toronto were on Lloyd's system, and comparatively light; the amount of change shown, corresponded remarkably with the two sets of instruments.

In reply to a question by Professor Mitchel, Prof. Bache stated that the observations made under Prof. Lamont's direction, had not been received.

4. On a Curious Fact in Relation to a Turbine Wheel. By Mr. T. Chase, of Massachusetts.

In computing the experiments which were made at Lowell in the present year, by Mr. Francis, it was found that, when the gate was

fully open, the quantity of water discharged through the guides, was 71 per cent. of the theoretical discharge. The effect of the wheel giving these experiments, was $81\frac{1}{4}$ per cent. of the power expended. But when the gate was half open, the effect was 67 per cent. of the power, while the discharge through the guides was 11 per cent. more than the theoretical discharge. But when the opening of the gate was still further reduced to one-quarter of the full opening, the effect was also reduced to 45 per cent. of the power; while the discharging velocity was raised to 49 per cent. more than that given by theory. In the first of these experiments, the fall was 12.9 feet; in the second, 13.28 feet; and in the third, 13.43 feet; and the quantity of water used upon the wheel with the full gate, was 135 cubic feet per second.

Prof. Peirce said that if in the last of these experiments, the wheel were removed, and the water suffered to run through the guides without obstruction, the head which would be required to give a velocity of discharge equal to that actually observed, would be about $37\frac{1}{2}$ feet. The effect of the interposition of the wheel upon the discharge, is, therefore, as much as 24 feet, which is about seven-tenths of an atmosphere.

V. On the Silurian Rocks of the Lake Superior Land District. By Prof. Jas. Hall.

[*Not received.*]

Mr. Desor said, that he considered the chief result of Prof. Hall's exploration of the Lake Superior Land District to be the extension of the New York system of rocks as far as this region. It had been a question, what was the limit of these rocks at this point. Was it a continent, or an island? In this respect, the discoveries of Logan had been highly important, since he had found, at a point sixteen miles north of Georgian Bay, a deposit of Niagara limestone, with all the characteristic fossils. This deposit, he thought, could be traced as far north as Hudson's Bay; therefore the limit of the New York rocks, in the vicinity of Lake Superior, would appear to have been rather an island, and not a continent.

This examination of Mr. Logan's revealed some interesting facts in relation to the drift. We find, on the shores of Lake Superior, limestone pebbles, with fossils, of the Niagara rocks. These have been referred, by some, to ledges in the vicinity, and on the bottom, of the

Lake, and, again, to a deposit on the south; but it is now shown that we have the Niagara limestones in the exact direction with drift currents.

Mr. Desor would also, in this connection, make some remarks of a palæontological character. It has been often assumed that we have, in lower Silurian rocks, a simultaneous, or contemporaneous development of the four great orders of the animal kingdom. In England, the remains of vertebrates have been found as low, only, as the Dudley limestone; in this country, only in the Niagara limestones, with, perhaps, some faint indications of spines of fishes in the Clinton group.

Now, within a comparatively recent period, Mr. Logan has discovered, in the Potsdam sandstone, near Montreal, distinct impressions of the foot-prints of reptiles, with accompanying trails.

These slabs had been submitted to the examination of Prof. Owen, of England, who had given his opinion in favor of their being the foot-prints of an animal allied to the tortoise.

By request, Mr. Foster then read the opinion of Mr. Owen, as given in a note accompanying the address of Mr. Lyell before the Geological Society of England.

Prof. Agassiz said, that, some time since, when he had advanced the idea of the existence of the four orders of animals, contemporaneously, in the Lower Silurian Rocks, the proposition had been doubted by the gentleman who now brings forward this evidence. Still, he did not believe these tracks could be referred to animals allied to the tortoise. The palæontological evidence we possess does not admit of this belief. If these are really tracks of vertebrata, there must be an organic connection between the animals which produced them and those which succeeded them, and whose remains we find in the upper rocks. We would rather refer these foot-prints to a species of fishes furnished with horny envelopes and plates, somewhat resembling turtles.

Mr. Desor rejoined that these tracks must be regarded in the same light as the foot-prints of the Connecticut Valley, and we must consider them without regard to the principles and theories which they would affect.

Dr. King suggested the propriety of exercising extreme caution in receiving such novel and startling discoveries as facts, in our geological inquiries. This was particularly important, so far as his investigations had gone, in relation to the Silurian Rocks of Missouri. He had frequently met with coal in such situations amongst them that it might readily give origin to the report of the proper existence of this mineral in that formation, but which, nevertheless, was not the case. He

referred to a mine of coal on the Osage River, in a portion of the formation which, according to the description of Prof. Hall, must be even lower than the Potsdam limestone. The coal of this mine had been penetrated to more than thirty feet in depth, and furnished the neighborhood with all the fuel of this kind they required. In his remarks on the Geology of Missouri, Dr. King would take the occasion to explain the condition under which this coal occurs, and show that it did not belong to the formation in which it is found, but, in all probability, to the carboniferous.

Prof. HALL said, he had every confidence in the position assigned by Mr. Logan to the rocks containing these tracks, yet he would not admit their connection with an order of animals higher than fishes. Even in the Clinton group, claws and tracks are very evident, yet he would not admit they were produced by reptiles, since, among the thousand remains of fishes contained in these rocks, we had not yet found any remains of reptiles.

Dr. KING inquired of Professor Hall if he recognized the Receptaculite as one of the fossils of that part of the formation formerly called "the cliff limestone," and which he now says he considers one of the lower Silurian rocks. Dr. King considered this as a highly characteristic fossil of the lead-bearing strata of the Upper Mississippi, and, as it occurs in Missouri, in conjunction with other fossils identical with those of the underlying blue limestone, or Trenton limestone, of that region, it became important in identifying the Missouri formations.

6. ON AN APPARATUS, CONSTRUCTED BY MR. WURDEMANN, FOR DETERMINING ALTITUDES BY MEANS OF THE BOILING POINT. By Prof. JOS. HENRY.

[*Not received.*]

7. ON THE MOTION OF THE SUN ABOUT THE CENTER OF GRAVITY OF THE SOLAR SYSTEM. By Prof. GEO. W. COAKLEY, of St. James College, Maryland.

[*Not received.*]

THIRD DAY: WEDNESDAY, MAY 7, 1851.

(Afternoon Session.)

The Association had an informal meeting from 3 to 4 P. M., for the purpose of examining geological and other specimens. Among these were various series of fossils from Ohio, and daguerreotypes of the moon, taken at the Observatory of Cambridge.

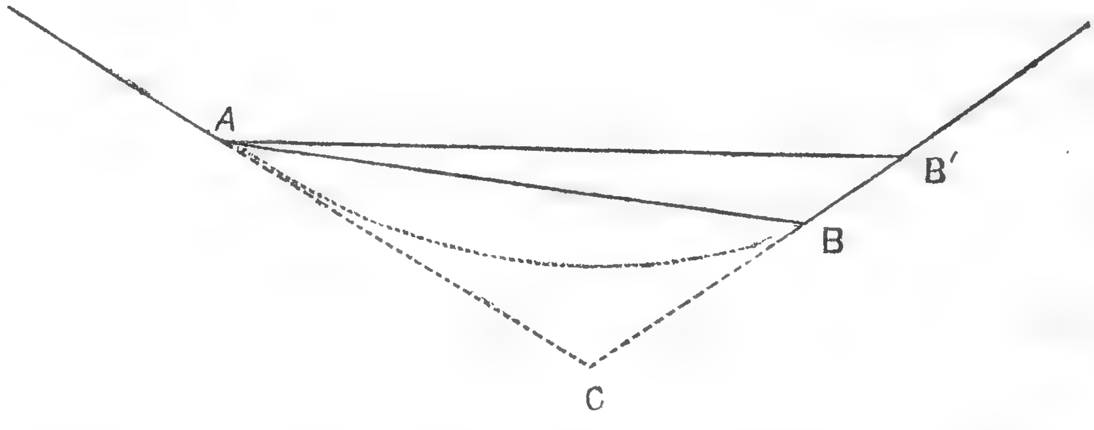
At 4 P. M., the Association was called to order by the President.

An invitation from a Committee of the Young Men's Lyceum of Natural Science, to visit their Hall at the Southwest corner of Western Row and George street, and examine their cabinet, was received and accepted.

The following papers were then presented :

1. On a New Curve for Railroad Tracks. By Rev. Thos. Hill, of Waltham, Mass.

It sometimes occurs, in running a curve, that it is convenient to join two tangents, as AC and B′C, at unequal distances from their intersection.



In this case, the following anomalous curve will be found, perhaps, more readily laid down by theodolite and chain, than any compound of circles. Let AB $= r$, BAC $= \phi$, ABC $= \epsilon$. Let $s =$ length of the curve, found by the empirical formula,

$$s = \left(\frac{\phi \cos \phi + \epsilon \cos \epsilon}{\sin \phi \cos \phi + \sin \epsilon \cos \epsilon}\right)$$

in which ϕ and ε are in terms of the radius. That is, if ϕ and ε are measured in degrees, the resulting value of s must be multiplied by $\frac{\pi}{180} = .01745.$

Measure or calculate the angle B′AB which one chain on the tangent B′C subtends at A, and let it be $\Delta\phi$. Then, if chains are the units of s, etc., let

$$\Delta^2 \phi = \frac{2(\phi - s\Delta\phi)}{s(s-1)1}$$

in which formula ϕ and $\Delta\phi$ may conveniently be used in minutes. $\Delta^2\phi$ ought to be negative, when $\phi \angle \varepsilon$, and zero when $\phi = \varepsilon$.

Now, placing the theodolite at A, measure one chain on a deflection of

$$\Delta_1 \phi = \frac{2\phi}{s} - \Delta\phi,$$

Measure the next chain with an additional deflection of

$$\Delta_1\phi - \Delta^2\phi = \Delta_2\phi,$$

and so on, in arithmetical progression. The sum of n deflections, or deflection of the nth chain, must be

$$\phi_n = n\left(\Delta_1\phi - \frac{n-1}{2}\Delta^2\phi\right)$$

When you have run in this way as far as convenient, and are obliged to move up the instrument, it will be necessary to repeat the calculations for the new positions.

When B can be seen from A, it is better to begin the chaining at B. In this case, the first deflection from the chord AB, is $\Delta^1\phi, = \Delta\phi,$ and the second additional $\Delta''\phi = \Delta^1\phi + \Delta^2\phi$, and the total deflection from a curve at the end of m chains, is

$$\phi[m] = m\Delta\phi + \tfrac{1}{2}m(m-1)\Delta^2\phi, = m\left(\Delta\phi + \frac{m-1}{2}\Delta^2\phi\right)$$

It will not be necessary, in calculating s, to go beyond tenths of a chain.

This curve, so easy in railroad construction, is rather intractable in analysis. If ϕ and r be polar co-ordinates, ε the angle of radius vector with the curve, s the length of the curve, and ϱ the radius of curvature—we have

$$\phi = as^2 + bs \qquad \varrho = \frac{rs^2\cos\varepsilon}{2(s^2\sin\varepsilon\cos\varepsilon + rs - r\phi)}$$

$$\sin\varepsilon = r(2as + b) \qquad a = \frac{s\sin\varepsilon - r\phi,}{rs^2}$$

$$b = \frac{2r\phi - s\sin\varepsilon}{rs}$$

It is an anomalous spiral, commencing at the origin, shooting out rapidly, and more slowly returning toward the origin, which it never reaches. In places where it is necessary to move up the theodolite frequently, the involute of a circle might be introduced. In this case, Δr would be in arithmetical progression, instead of $\Delta \phi$, and the instrument would be moved up at every chain. The radius of the evolute circle will be $R = \dfrac{r(\cos \epsilon - \cos \phi)}{(\sin(\phi + \epsilon))\,(\phi + \epsilon - 2\tan\frac{1}{2}(\phi + \epsilon))}$.

The initial value of $\varrho = \varrho_0$ is $\varrho_0 = R\,(\phi + \epsilon - \tan\frac{1}{2}(\phi + \epsilon)) + \dfrac{r\cos\phi}{\sin(\phi + \epsilon)}$; the initial deflection is $\frac{1}{2}\Delta r =$ arc sin $\dfrac{1}{2\varrho_0}$; the unit being a chain, except for angles where it is radius as above. The deflection of the second chord from the first is $\Delta r + \Delta^2 r$;

and $\Delta^2 r$ is constant. $\Delta^2 r = \dfrac{2(\phi + \epsilon - (s+1)\,\Delta r\phi)}{s(s+1)}$.

2. Report of the Committee upon Prof. Mitchel's System of Astronomical Observations. By Prof. B. Peirce, Chairman.

The Committee appointed for the examination of Prof. Mitchel's method of observing Right Ascensions and Declinations, by the aid of Magnetism, respectfully report, in part:

They have made a preliminary examination of Prof. Mitchel's apparatus, and of his books of observation. Everything has been freely opened to a rigid scrutiny, which has been sought, earnestly, by the astronomer himself; and they have felt it to be their duty to investigate every reasonable, and even every possible source of doubt and error, with patience and fidelity. They would have preferred to postpone all expression of opinion to the next meeting, if they had not regarded it as being of the first importance to relieve anxiety upon this subject, as soon as they had proceeded sufficiently far in their inquiries to be quite sure of the final result. They are not, however, prepared to enter into minute detail at the present meeting, but must confine themselves to general forms of expression. They intend also to avoid, at the present time, the consideration of the questions of priority.

1. Prof. Mitchel's apparatus for observing Right Ascensions, is thought by the Committee to sustain all his claims in regard to its

simplicity, accuracy, facility and dispatch. It is a fine specimen of ingenious contrivance; and the best proof of its superiority in this respect, is the fact that, notwithstanding the roughness of construction to which the inventor has been forced to submit by his limited resources, it rivals, in the accuracy of its results, the most finished specimens of skillful workmanship. By the use of two pens, he has avoided all possibility of the peculiar error which must constantly arise, whenever the same pen is used for recording the observations and the clock-beats. By recording upon a disk, with a pencil which makes a slight dot at a single swift stroke, he has reduced to a minute quantity the perturbations in the motion of the disk, which arise from the act of recording. The methods for adjusting the disk and reading its record, exclude all danger of error from imperfect centering, while the ingenious apparatus for reading admits of great nicety and rapidity in the execution of this task. The attention which has been paid to the determination and elimination of minute sources of error, such as armature time and the like, deserves high commendation.

2. In regard to the apparatus for observing Declinations, the Committee report, in some respects, with less confidence, because the series of observations, although quite various, is not yet sufficiently extensive. They think, however, that they may venture to report upon the probable capabilities of the apparatus, and the limit of accuracy which it may be expected to attain, and which it may already have attained. The principles of its construction are regarded by the Committee as perfectly correct, and as exhibiting a happy combination of ingenuity and originality. They are surprised and delighted at the simplicity with which all danger of error from eccentricity or flexure is avoided, as a partial equivalent for which it may be important not to overlook any short lateral motion of the pivot of the telescope in its socket. In its present form, the apparatus must be considered to be purely differential, and to depend upon other fundamental observations for the determination of the length of its arc. With this condition, the measurement of differences of declination may extend to the degrees, and perhaps much further, without any loss of accuracy. The principal feature which characterizes this apparatus, and distinguishes it from all others, consists in its admitting of the observation of ten different horizontal wires during a single transit; and these observations are made with great facility, without mental tension, and so close to the meridian as to involve no difficulty in their reduction to the meridian.

By an additional piece of mechanism for some observations, these

may be conducted with unsurpassed rapidity, and sufficient exactness, without risk of confusion or any perplexity of thought on the part of the observer.

Finally, the Committee are not aware that the history of astronomical science exhibits a more astonishing instance of great results produced with what would seem to be wholly inadequate means. With the ordinary tools of a common mechanic, and with insignificant pecuniary outlay, an isolated individual has aspired to rival the highest efforts of the most richly endowed institutions, upon which sovereigns and governments have showered their inexhaustible patronage; and his aspirations have been crowned with success. The Committee are persuaded that under more propitious circumstances, and with more generous opportunities, Prof. Mitchel's plans of apparatus will lead to still more admirable results, and contribute yet further to the advancement of astronomical science. (*Signed,*)

BENJAMIN PEIRCE,
CHARLES WILKES,
SEARS C. WALKER,
J. H. C. COFFIN,
SAMUEL ST. JOHN.

Prof. BACHE remarked that the value of this decided and perspicuous report, was enhanced by the cool, investigating character of the members of the Committee, and the practical and theoretical knowledge which they had brought to their task. The circumstances attending the reception of the description of Prof. Mitchel's invention at the New Haven meeting, further increased its value. It was not surprising that those versed in the methods of astronomical observations in established use, should be skeptical in regard to the performance of an apparatus avowedly constructed with imperfect means, and startled when its results were stated as vying with those of perfect instruments, imported or made at a great cost. These opinions were freely expressed, and no considerations of private friendship were allowed to interfere with a protest which seemed to many members of the Association to be necessary against the pretensions thus set up. Prof. Mitchel did not doubt, but with a manly love of truth, courted examination, and invited those who objected to make the closest scrutiny of his results. This has been done at the present meeting. The Committee has carefully, and with great minuteness, investigated the whole apparatus, its action, and its results; they have given a considerable portion of their

time to this investigation, and now unanimously report that they are satisfied that the claims set up for this method as a marked improvement are real. It goes out, then, with the stamp of this Association; it has passed a critical ordeal, and stands by its merits, as one of the most important steps ever made in our country in the progress of astronomical observation.

Prof. MITCHEL remarked that, on presenting to the American Association an account of the new machinery for the registration of astronomical observations in Right Ascension and Declination, he was not at all surprised that the results reached by such apparently inadequate means, should have produced a powerful revulsion, and that there should have arisen a seeming rebellion against these presentations, in the minds of the most judicious and conservative members of this body. But he had no where else to go, but to the American Association. The instruments were complex in their character, difficult to be understood, and requiring minute inspection and personal examination for their full comprehension. And when doubts were expressed, by high authority, the only course was to challenge the most rigid examination. The high standing of the Chairman of the Committee to conduct this examination, was well known, and his report had just been presented. Prof. Mitchel would not attempt to express the gratification afforded by a confirmation of his own views of these methods by the opinions of such gentlemen as those composing this Committee. He could only say, that however severe the demands of the Committee might be on the performance of the machinery, his own demands would be infinitely more stern and unyielding in their character.

On motion of Mr. COAKLEY, it was resolved to offer the report of Prof. PEIRCE to the city papers, for immediate publication.

3. ON THE FOSSIL RAIN-MARKS FOUND IN THE RED SANDSTONE ROCKS OF NEW JERSEY AND THE CONNECTICUT VALLEY, AND THEIR AUTHENTIC CHARACTER. By W. C. REDFIELD, Esq., of New York.

IN a short notice of some newly discovered fish-beds, and a fossil footmark in the Red Sandstone, at Pompton, in New Jersey, published in the forty-fourth volume of Silliman's Journal, First Series, I took occasion to refer to numerous slabs and fragments, in the quarries at Pompton, which exhibited fossil impressions of rain-drops, or hail, and natural casts of the same, in relief. I stated, that, while there was great variety in the impressions, (as regarded different slabs,) some of

the specimens were of the most perfect character; while, in not a few cases, the oblique form of the impressions served to show that the drops had been driven by a strong wind. The angular forms, as well as the obliquity, of some of the impressions, appeared to be due to a storm of hail.

Other impressions, of this character, had been found, by Professor Hitchcock, in the sandstone rocks of the Connecticut Valley. My first observation of the rain-marks was in 1842, in company with Sir Chas. Lyell, when I found a good specimen in the old quarries at Newark. From this time I had given careful attention to the recent impressions of rain on various surfaces, and to those made on unburned bricks, preserved by subsequent exposure to heat in the kiln. I brought off a considerable number of specimens from the quarries at Pompton, which were the finest and most satisfactory that I have yet seen. Suits of these, showing the various action of rain, under different circumstances, I have furnished, at different periods, to Sir Charles Lyell, and to Professor Rœmer, at Bonn; so that my stock of good specimens is nearly exhausted. I am sorry to say that these quarries are no longer worked; so that choice specimens are not easily found at this time. Some small and inferior specimens I submit, at this time, to the inspection of the members; and the examination of these, I trust, will be sufficient to remove all reasonable doubts of their true character.

In the printed Proceedings of the Boston Society of Natural History, I have noticed an attempt to account for the origin of these impressions, by ascribing them to "air-bubbles, formed in the waves of the surf, when rolling over the beach." If the impressions from the Pompton quarries had been seen, and compared with the bubble-marks thus referred to, I feel confident that this hypothesis would not have been relied on for explaining the impressions. It is stated that the bubble-marks are of various kinds, as seen forming at the same time. But the rain-marks, on each separate slab, are more generally uniform; while different slabs show the varied effects of rain under different circumstances and conditions. Moreover, the rain-marked surfaces show, by various indications, that they could not have been exposed to the action of the surf, or waves. The impressions are usually found on a thin covering of clayey matter, such as is deposited from small and shallow pools, after a rain, and which lies, generally, upon a harder surface, and would have been at once removed by the washing of waves. Nor would the firm consistence of the substratum allow of any

free escape of air-bubbles from below, as in the case in soft and oozy deposits of mud.

I have met with no practical geologist who, on examining the New Jersey specimens of rain-marks, was not satisfied of their genuine character. Mr. Lyell has given much attention to rain-impressions, since our discovery of the specimen at the Newark quarries; and in a letter which I lately received from our fellow-member, Mr. Hodge, occurs the following extract:—"Mr. Lyell also wished me to say to you, that he had examined, with Mr. Logan, a great number of recent rain-impressions upon clay, and compared them with those ancient ones you have brought to light in the Red Sandstone of New Jersey, and they both are entirely satisfied that the opinions of Mr. Desor are altogether unfounded, and that your views are correct as to the origin of these impressions."

Mr. Desor would not deny that there existed genuine impressions of rain-drops, in various sandstone formations. He considered especially as such those which are surrounded by a rim, and are elongated in a uniform direction, showing that the rain was driven by the wind. But there are found, in the Potsdam sandstone of Isle Royal, slab-impressions of larger size than the common rain-drop marks, frequently half an inch in diameter, and without any rim. These, he thought, could not be rain-drops; having found them, in every respect, similar to those impressions made by the air-bubbles when bursting on the sand-beaches, during the surf. He should be inclined to consider all those impressions as bubble-marks, unless the absence of a rim could be satisfactorily explained. Those of Lake Superior were without any rim.

Mr. Redfield said, that he had noticed marks on the Potsdam sandstone which, he thought, could not have been produced by rain. They appeared like the prolonged effect of continued drippings of water in different spots, from some substances suspended above the surface of of the ground.

Prof. Merrick had had an opportunity of comparing the effect of rain-drops upon the recent sand, and those upon the sandstone, in immediate proximity. While engaged in examining the sandstone in the vicinity of South Hadley Mass, a shower occurred, and the impressions upon the sand of the river beach produced marks precisely similar to those on the sandstone. All the variations of form produced by the wind driving the drops of rain forward, were perfectly represented upon

the sand by the recent rain-drops as upon the ancient rock. The relative position of the impressions were also strikingly similar. He had also noticed the impressions of hail-stones, in connection with those of rain, upon the sandstone of Newark, N. J. The angular form of the hail was distinctly seen. The thin film of clay, which covered the sand, was removed, and the sand somewhat displaced. The diameter of these impressions was from half to three-fourths of an inch.

Mr. Redfield remarked, that he had observed that the rain-drop impressions on the sandstones of New Jersey had an oblique form, owing to the direction of the wind, and that this direction was given by a westerly wind, the same point from which violent thunder squalls now come. These are, therefore, the oldest meteorological records—records reaching back to the Triasic period.

Prof. Henry inquired, what was the form of these impressions?

Prof. Merrick replied, a little convex upon the surface.

This Prof. Henry had inferred from the form of the drop. This, in its passage through the air, tended, at first, to become spherical by capillary attraction, and then to be flattened, and even to become concave, on the lower side. In this condition, a contractile force is developed which tends to form the reversed disk, if I may so describe it, into a hollow sphere, which explains the accumulation of the matter in the center of the impression.

4. On the Determination of the Velocity of Sound, by the Method of Coincidences. By Prof. A. D. Bache, LL. D.

This method occurred to me about the year 1832, when observing the marching of the corps of cadets across the plain at West Point, to martial music, and at quick step. At first the left foot was brought to the ground in the cadences of the music; soon it appeared as though step was not kept to the music; and as the music and the marching body receded, the right foot appeared to strike the ground in the cadences. There was a succession of such alternations. This suggested the idea that by providing a regular series of alternate motions, any remarkable phase in which was simultaneous with a sound, and moving at a suitable distance, corresponding to the loudness of the sound, and with proper appliances to assist the sight, a very simple and exact mode of determining the velocity of sound would be had. With such a method sounds of different qualities could readily be employed, so as perfectly to test the usually received doctrine, that the quality of a sound has

no influence on the velocity of its propagation. The ease with which such experiments could be made, would permit the experimental solution of many questions in regard to the circumstances influencing the velocity of sound, at present but imperfectly resolved.

I tried many imperfect experiments in this method in 1834, and ascertained that the limits of distance over which the uncertainty in the determination of a coincidence in sight and sound extended, would not interfere seriously with the accuracy of this determination. The want of means to procure a suitable apparatus, prevented me from prosecuting these experiments, which I had almost lost sight of, when they were recalled to my mind by the methods of determining the limits of perceptibility of direct and reflected sounds, in the interesting experiments described to the Association by Prof. Henry.

I ought not to omit the statement that, in describing my experiments to the late Prof. Adrain, of the University of Pennsylvania, he informed me that the same idea had occurred to him several years previous to my communication to him, but had not been carried into execution.

Prof. Coffin remarked that the idea suggested by Prof. Bache, of a pendulum operating by means of an electric circuit, as a method of producing a regular sound, was capable of an interesting and important development. By such a connection, the pendulum might not only produce a sound at its own location, but also at the station of the observer, and thus the observation would be reduced to noting the coincidence of two sounds; or a regular motion, coincident with that of the pendulum, could be brought immediately under the eyes of the observer; or the pendulum itself be located near him, and under his direct control; or by means of registers, such as have already been introduced into astronomical observations, the pendulum could record its own vibrations.

In such ways, an interesting variety may be introduced into a series of observations, and a new importance and accuracy secured to the results.

5. On the Goniatite Limestone of Rockford, Jackson County, Ind. By D. Christy, Esq., of Oxford.

Mr. President: I have but a single fact to communicate to the Association. It is this: that certain species of Goniatites, described in Europe as Carboniferous fossils, are central in the Black Slate of

Indiana. This Slate, in that State, as elsewhere in the West, rests upon the Cliff Limestone. The point of interest to the geologist, in this discovery, is, that it brings down the Carboniferous system much lower than it was supposed to exist.

The examination which led to this result was undertaken at the urgent request of M. de Verneuil, of Paris. It was my good fortune to make the acquaintance of that distinguished Palæontologist, during his visit to this country in 1846. In forwarding to him, subsequently, a few boxes of fossils, in exchange for those of Europe, I included three species of Goniatites from Rockford. These were determined to be *G. rotatorius*, *G. princeps*, and *G. cyclo-lobus*, all of which are Carboniferous fossils—the first two belonging to the Mountain Limestone of Belgium, and the latter to that of England.

In 1848, M. de Verneuil communicated to me his intention of describing and publishing the Goniatites of America, and requested me to visit Rockford to obtain as many associated species as possible, and to examine particularly their geological position. Dr. D. D. Owen, he said, had presented him some Goniatites from that locality, and had assured him they were from the strata beneath the Cliff Limestone. But M. de Verneuil said he could not be persuaded that this was their true position, until the locality should be again visited, and more carefully examined than Dr. Owen's hasty reconnoissance had allowed. He said that, until then, he must conclude they were above the Black Slate, and not beneath it.

In the course of 1849 a visit to Rockford was accomplished, but time permitted an examination only of its vicinity. The result was a confirmation of Dr. Owen's opinion. But it was suggested to M. de Verneuil, as a solution of the mystery, that the Black Slate of the West, may be only a continuation of the superior strata of the corresponding series of shales in Pennsylvania, where that immensely developed formation unites with the Carboniferous rocks. These shales, in Pennsylvania, are estimated, by Prof. Rogers, at a thickness of six thousand feet. But in Ohio, this formation has thinned down to three hundred and fifty feet, and in Indiana to sixty or seventy feet. It was therefore concluded that the Western continuation of the inferior strata of the Carboniferous rocks of Pennsylvania, must rest upon the Cliff Limestone of Indiana, and that the Goniatite Limestone of Rockford, with all the overlying strata, belongs to the Carboniferous period.

In January, and again in April, 1850, M. de Verneuil wrote me, that he was progressing with his publication of our Goniatites, and

urging me very strongly to revisit Rockford, and make more extensive investigations. It was most important to him to refer them to their true geological position.

In complying with this request, I not only ascertained the true position of the Goniatites, but, through the politeness of Drs. Williamson and Hillis, and other citizens of Rockford, I obtained two or three species of Cyrtocera, three or four of Orthocera, and as many of Cyathophyllæ, in the Goniatite Limestone.

These fossils are found in a bed of impure Limestone, which, I was informed, could not be burnt so as to slack. It is only exposed at very low water, in the bottom of the river, immediately below a mill dam, occupying only a few square rods. In ascending the river, three miles north-east from Rockford, the Black Slate was found at the mill of Mr. Yonts, thirty feet in thickness, occupying the bluffs and bed of the river. The dip being south-west, shows that this slate is above the Goniatite Limestone. The slate is no where, in this neighborhood, exposed beneath the limestone; and both Dr. Owen and myself were thus led into error, and supposed that this rock constituted the upper strata of the Cliff Limestone.

In extending the examinations, a point on the Vernon fork of Muscatatack was next visited, seven miles southeast of Rockford, at Wheeler's Mill, where twenty-eight feet of the Black Slate is exposed in the pot-hole below the dam, and in the bluffs. At one point this slate is overlaid by a thin stratum of limestone, but destitute of Goniatites. Mr. Wheeler accompanying me, we passed up the mill pond, southeast, a mile and a half, to his stone quarry, and found a massive bed of limestone resting upon the slate, a little above the water's level. The course of the river is nearly with the *strike* of the rock, and the strata are almost horizontal. At the quarry we found, after close search, two Goniatites, with a few other fossils, all identical with those of Rockford. Here, now, we had the Goniatite Limestone, with at least twenty-eight feet of Black Slate beneath it.

Extending our investigations up the valley, nearly east, to where a bayou reaches a high bluff, we found thirty feet of Black Slate above the limestone, but on account of the slaty debris at its base, the latter rock could not be seen. This discovery settled the question, that the Goniatites are not in the Cliff Limestone, but central in the black slate.

In passing westward from Oxford, Ohio, to Rockford, the geological section to which I would call your attention, first presents an outlier of the Cliff Limestone upon the Blue Limestone, at Napoleon, Indiana,

twenty-seven miles northeast of Scipio, on the Madison and Indianapolis railroad. At Scipio the Cliff Limestone dips beneath the outliers of the Black Slate, and in a few miles is lost to view below the slate and drift. Rockford is eleven miles from Scipio, on this same southwest line. Without a knowledge of the rate of dip of the strata, it will be seen how easy it was for any one to conclude that the Goniatites are in the Cliff Limestone. If the dip were only half what it is, the latter rock could not have sunk below the river's bed at Rockford.

Dr. Owen, in his report on the geology of Indiana, I was told, estimated the thickness of this slate in this region, at only twenty-five feet. At Yont's mill there is at least that thickness, and no other decision could have been made, than that the Rockford limestone belongs to the cliff. A little reflection, however, satisfied me on my last visit, that the Black Slate must have a greater thickness than twenty-five feet. The Cliff Limestone must be nearly two hundred feet thick, and it had disappeared in a nearly level country, beneath the slate, in about thirty miles. In fourteen miles, therefore, more than twenty-five feet of slate would disappear—there being no change of the rate of dip.

But a second section, the materials for which were obtained on my homeward trip, affords the means of deciding the question, even had no Goniatites been found at Wheeler's mill. At Queensville, a few miles east of Scipio, on the railroad, the Black Slate caps the hills, leaving fifteen or twenty feet of the Cliff Limestone exposed in the banks and bed of Six Mile creek. From Queensville, my section extended southwest to Wheeler's mill, a distance of thirteen miles. Five miles from Queensville on this line, at Judge Whitcomb's, the slate has reached the bed of Six Mile creek, and the Cliff Limestone disappears beneath it. The latter rock is well exposed in the banks of the creek, the whole five miles. The stream itself must have a fall of near three feet to the mile, or fifteen feet in this distance. In five miles, then, the limestone has sunk nearly thirty feet, making its dip six feet to the mile. In the next eight miles, therefore, to Wheeler's mill, the strata must sink forty-eight feet, if our approximate estimate of the dip be correct. This would leave the thirty feet of slate at the bluff, northeast of Wheeler's mill, above the level of the Goniatite Limestone. At the mill, twenty-eight feet lie below it. This, then, fixes the Goniatites central in the Black Slate.

Six miles below Rockford, the hills of gray and bluish soft shales are found, the lower strata of which being so near the level of the

valley, as to lead to the conclusion that the upper Black Slate is not much over thirty feet in thickness. In continuing the section southwestward to the Muscatatack hills, we have, overlying the Black Slate, about three hundred and fifty to four hundred feet of soft shale, with an occasional stratum of limestone, and some beds of sandstone, including fossils. At the summit of the Muscatatack hills, which are about five hundred feet in hight, the Mountain Limestone is finely presented. Tracing it to where the coarse sandstones and coal overlie it, a thickness of three hundred and fifty feet is indicated.

Should the European geological subdivisions be adopted in this country, it will be seen that this discovery will require us to bring down our Carboniferous rocks to the center of the Black Slate, or within about thirty feet of our Cliff Limestone. A reference to the Ohio Geological Reports, will show that the Waverly Sandstone occupies nearly this position in Ohio, and the Goniatite Limestone of Rockford may be its equivalent.

Allow me, now, Mr. President, to place another fact upon record, in connection with your transactions in the West. I have had some parcels of the Indiana gold, with its black sand, sent to me. Mr. Wheeler was one of those who collected some of this gold. He pointed out to me the spot where it was obtained. It was at the junction of the Drift with the older rocks. The statements of all others correspond with Mr. Wheeler's, so that the gold of Indiana is of diluvial origin.

THIRD DAY: WEDNESDAY, MAY 7, 1851.

Evening Session.

The paper of the evening was as follows:

1. Results of an Exploration of the Coral Reefs of Florida, in Connection with the U. S. Coast Survey. By Prof. L. Agassiz.

It had recently been his good fortune, said Prof. Agassiz, to have an opportunity of exploring the Reefs of Florida, under the auspices of the U. S. Coast Survey, with a view of investigating the character of the coast, and the structure of its extensive range of corals.

The Superintendent of the Coast Survey, Prof. Bache, had afforded him every facility for prosecuting his investigations, and had desired him to report the results obtained, with a view of being useful to the topographical investigations going on under Prof. B.'s direction. Prof. Agassiz expressed his great obligation to the Superintendent and the intelligent officers of the Survey, for the assistance and information which had enabled him to obtain results which might otherwise have required months, and perhaps years, of careful observation. He hoped these results would prove as useful, as they had been instructive to himself.

At the outset, he would say that the coral reefs of Florida differ entirely from the coral reefs of other seas, which have been so ably described by Messrs. Dana and Darwin—by Mr. Darwin of the British Exploration, under Captain Fitzroy, and by Mr. Dana of the United States Exploring Expedition, under command of Capt. Wilkes.

In order to point out the peculiar characteristics of the Reef of Florida, it would be necessary to speak of the reefs of other regions, and particularly those of the Pacific. These are divided into three classes, viz: the Fringing reef, the Barrier reef, and Lagoon or Atoll islands. The characters of each of these divisions fully justify such a classification. But in the case of the Florida reef, the coral formations extend in *several* parallel ridges between the main land of Florida and the Gulf Stream, in a westerly course, diverging more

and more from the main land, until, near Cape Sable, they are forty miles distant, stretching like a broad arm into the Gulf of Mexico, and extending in a southerly direction into the rapid current of the Gulf stream. The Pacific ocean reefs, on the contrary, grow in the open sea, and differ essentially in character from those of Florida.

The principal reef of living corals in Florida, occurs between the main Keys and the rapid sea current which runs between Cuba and the islands encircling the main land of Florida; but other coral deposits of a peculiar nature are found to exist around, upon and between the Keys and the main land. The combined action of the tides and currents produces eddies, in which fine sand, and even mud, is deposited around the reefs. These materials Prof. Agassiz considered to be minute fragments of corals, of an impalpable powder, held in suspension by the water, which is rendered milky-white by their presence. At a short distance beyond, the water becomes clear.

The three classes of coral reefs distinguishable elsewhere, were explained by Prof. A. with the aid of blackboard diagrams. First, the "fringing reefs," secondly, the "barrier reefs," which form rising walls at some distance from the main land, between which and the land a broad and safe channel frequently exists; and, thirdly, the "lagoons," or atoll islands, which present circular walls, sometimes continuous and sometimes broken up. The lagoons often constitute accessible and safe harbors. These encircling reefs are formed in a manner similar to the barrier reefs, by the growth of coral from various depths to the surface. The formation of the two latter classes of reefs has been ascribed to the subsidence of the bottom, combined with the upward growth of the corals.

The range of living reef building corals has been ascertained to be limited between a depth of sixteen to twenty fathoms, and a few inches below low water mark—for, unless constantly submerged, they die; but they are frequently found dead at enormous depths, forming very precipitous walls of coral rock.

In Florida we have no barrier reef, but a series of *concentric* reefs, enclosing parallel channels, formed without the slightest indication of submergence or upheaval. These are the outer reef, the Florida Keys, and the shore bluffs, with the main channel south of the Keys; the mud-flats between the Keys and the main land, with a slight depth of water, often not more than two feet; and flat, low islands, on which there is an extensive growth of mangroves. The Keys rise from ten to twelve, seldom more than thirteen feet above the level of the ocean.

Near the shore, there are mud and coral accumulations, which are evidently the results of the decomposition of the solid parts of the corals themselves.

Beyond the Keys, the channel is from five to six, and seldom more, fathoms deep. Its boundaries are frequently indicated by small islands or shoals, some of which form very dangerous reefs, such as Carisford reef. It is within this channel that the wreckers take up their abode, being safely sheltered from the strong gales which blow, frequently, outside, behind the walls of the outer reef, and the bar islands rising for a few feet above the level of the ocean. No coast, said Prof. A., would be more secure and safe for navigation than this, if it was properly understood; for every twenty miles there is a broad and safe harbor to run into. But, at present, it is perhaps more dangerous to know of these harbors, than to be ignorant of their existence; for the lights and signals along the shore, are all without reference to these places of refuge.

Adverting to the geological and zoological character of the general reef, the Professor remarked that it was important to ascertain whether, as reported by some, the reef consisted of dead corals only; or, as others maintained, was composed of living corals, still growing and extending; or whether, as it had been asserted by others, it consisted only of oolitic rocks, containing no indications of corals whatever.

All these arguments are found to be consistent, with the qualification that the three classes occupy different localities. On the outer reef, from Cape Florida, to Key West, in from ten to twelve fathoms up to the surface of the water, living corals are found, greatly differing, however, in constitution—the Madrepores (*Madrepora palmata*) especially, rising to the very surface, while the commonly so called Brain coral (*Meandrina*) occurs in lower, and the *Astræa* in still lower levels. Specimens of the different species were exhibited. The *Madrepora palmata* forms extensive fields of powerful stems, branching and expanding near the surface into large flats, resting upon strong bases, and presenting the appearance of large leaves spread out. The Professor characterized these fields as a wonderful spectacle. This extensive growth does not occur, however, further than one or two fathoms below the surface. Lower down a number of other species are found.

When a growing reef has thus attained its maximum hight, or reached the level of low water, a new process begins, consisting chiefly in the accumulation of loose materials upon its summit. Large coral bowlders are thrown up, and gradually ground into fragments, coral

gravel and sand, and finally deposited in more or less regular beds, presenting all the complications of torrential stratification, which are finally cemented, by the infiltration of amorphous limestone, into compact coral rock. When the materials are combined in a coarse state of decomposition, they form a kind of coral breccia; but when cemented after they have been reduced to small globular fragments, they constitute a sort of oolite, and even compact limestone, when the deposit is formed by precipitation. Thin layers of such compact limestone occur frequently as dividing seams in the larger masses of oolite; and there is every where such a layer of compact limestone upon the surface of all coral rocks rising above the level of the sea; a circumstance which seems to indicate that such layers are not formed under a permanent sheet of water, but must be the result of action of gales, and the spray. This is the more probable since this superficial crust is no where horizontal, but follows all the irregularities of the soil.

If it were asked how corals which, during their growth, have withstood so effectually the violence of the sea, become such an easy prey of the waves after the reef has reached the surface of the water, it would require only to point at the innumerable boring shells and worms which establish themselves in the dying part of their stems, and at the brittleness arising from these perforations, to satisfy every careful observer that the peculiar mode of life of these boring animals, is a provision of nature subservient of the secondary purpose of the corals, to furnish materials for the increase of the solid parts of our globe.

Along the outer reef of Florida, and in the main range of Keys, many islands might be selected and described, in such an order as to form a natural series from a living reef, without a dead fragment upon its edge, to an extensive island, apparently formed entirely of coral rock or of oolite, or even of compact limestone; but, in reality, presenting only a cap of such dead materials, overlying a true reef, once living, and now buried under its own fragments.

The circumstance that the main keys, and the shore bluffs, which have been formed successively, rise to the same hight above the level of the ocean, is an unquestionable evidence that the ground over which the general reef of Florida extends, has undergone no change of level, that it has neither been raised nor subsided. This evidence may be carried further, by comparing also the Everglades, with their intervening ridges and hammocks, which are, in reality, inland keys and islands, similar to the main keys and Mangrove islands, formed in the same manner as those now surrounded by the sea, and which, by the

uniformity of their level, furnish additional evidence that the whole region has been stationary ever since corals began to grow in those latitudes.

At 10 o'clock, P. M., the Convention adjourned.

FOURTH DAY: THURSDAY, MAY 8, 1851.

THE Association met at 9, A. M., in special session, to hear the following paper:

1. REMARKS ON THE SEXES AND HABITS OF SOME OF THE ACEPHALOUS BIVALVE MOLLUSCA. By JARED P. KIRTLAND, M. D.

THE fluviatile Bivalves of North America are principally included in the genera Unio, Anodonta, and Alasmodonta, and are appropriately arranged in the Lamarckian family of NAIADES.

In the waters of the State of Ohio are found sixty-four or sixty-five species; perhaps, a larger number.

Cuvier placed them among the Acephalous Bivalve Mollusca.

Most naturalists and anatomists have considered them as hermaphrodites; though that some discrepancy of opinion has been entertained on that point, may be seen, by referring to Mr. Say's article "Anodonta," contained in the second number of his American Conchology.

Familiarity with their habits, and a series of dissections, conducted without the aid of books, guides, and the necessary instruments,—and perhaps not in the most scientific manner,—convinced me, that the commonly received opinion was incorrect. In the twenty-sixth volume of the American Journal of Science and Arts, I stated, that "the sexes are distinct, and that each sex possesses a peculiar organization of body, associated with a corresponding form of shell, sufficiently well marked to distinguish it from the other." A diagram, illustrating the several differences of form in the shells of five species, was also published.

This conclusion was founded upon the facts, that very many species present, in their shells, two varieties of forms, in about equal numbers, and that, with one form, is associated animals with oviducts, which, at

certain seasons, teem with young, while the inhabitants of the other form remain permanently barren. Subsequent investigations have shown, that it is applicable to about two-thirds of the American species. In a few others, no difference in form is discernable between the shells of the prolific and barren varieties.

The animals of one species,—the *U. plicatus* of Say, are always barren, so far as I have observed.

Opportunities for examining a few rare species have not been afforded.

Without positive demonstration, by dissections, of the existence of the sexes in different individuals, that view may be controverted; yet it seems to have gained credence among our western collectors and naturalists most familiar with their habits.

It has recently been stated, in the Iconographic Encyclopædia, under the head of Zoology, page 70, that "Lamarck considered these mollusca as hermaphrodite; and the dissections of competent anatomists, such as Neuwyler and Van Beneden, confirm this view."

In the same article, an attempt is made to explain the cause of the occurrence of two varieties of form in the shells, in the following manner: "If some individuals remain barren, through a course of years, it is possible that the weight of the gravid branchiæ may cause the soft parts to descend, and bring with them the shell-secreting mantle, which may account for the enlargement, without recourse to the theory of separate sexes, which are not found in the allied families."

The writer, however, admits that this will not account for the second form of the *U. velum*, or *flexuosus*, and the extraordinary transverse diameter of the *U. siliquoideus.*

Let us test the correctness of this mechanical hypothesis, in its application to some other species.

Before you, is exhibited the shell and animal of the *U. ventricosus.* Its branchiæ contain no young, and their want of development shows that they have never been prolific. Yet the form of the shell is that in which the prolific animals of this species always exist; and it may be seen that the form has been gradually shaping itself, for the last three years, to that which I consider the female. She was yet too young to become prolific. Some other cause for the rotundity and fullness of the posterior margin must, therefore, be assigned than the weight of the *gravid branchiæ.*

The female of the *U. leptodon* (the *Velum* of Say) is characterized

by a broad, membranous expansion, which begins to form several years before the animal is productive.

Here are the female forms of the *U. torsus* and *subrotundus*:—An oblique sulcation below the superior-posterior angle, distinguishes them from the males. This sulcation could not be produced by the mechanical drawing down of the mantel. A similar sulcation exists in males of the *U. sulcatus* and *personatus*, but not in the females, while the latter, as well as the *U. triangularis*, are remarkable for the tumidity of their posterior and inferior angles, the margins of which are armed with an annual growth of teeth, or serrations, characters which are absent in the males, and the growth of which is not explained by that hypothesis.

The females of the *U. alatus* and *verrucosus* of Raf. and *Anodonta plana* are more tumid, shorter, and less transverse, than the males. How can the gravid branchiæ contract and shorten in some species, and develop in others?

Again, the *Alasmodonta edentula* affords about an equal number of barren and prolific specimens, yet no difference in the form of the shell is discoverable. Why does not this mechanical cause operate in this species?

We might as well attempt to explain the expansion, at the age of puberty, of the osseous frame of the female pelvis, in the human subject, by this mechanical theory. It is not tenable. We will, therefore, return to the main point of our subject—Are these mollusca hermaphrodite?

Competent anatomists, such as Neuwyler and Van-Beneden, we are informed, have decided this question in the affirmative.

The means of knowing the precise nature and extent of the discoveries they have made, have not come within my reach. A principal object in bringing the subject before this Association, is, to obtain information upon this point from members who are present, and are competent to render it.

If minute dissections, aided by the microscope, have discovered and demonstrated the existence of both male and female organs in the same individuals, of course, I must abandon the position I have taken, but if their hermaphrodite structure be a mere matter of inference, as I suspect, drawn from the failure to discover any anatomical difference between the prolific and barren individuals, then the probabilities are in favor of their being diœcious.

In the absence of any particular information in regard to the disco-

veries anatomists have made in reference to it, I will observe that the mollusca present examples of all modes of generation; some are hermaphrodite, others are diœcious. Several possess the faculty of self-impregnation; others, though hermaphrodite, require a reciprocal coitus: and the mode of fecundating, in those in which the sexes are distinct, is not, in all instances, understood.

The sexes of the CEPHALOPODA are distinct, the male and female organs being found in different individuals.

The PTEROPODA are all hermaphrodite, and their sexual organs are discoverable.

In some of the GASTEROPODA the sexes are separate, in others united.

Though the 4th class of Cuvier's mollusca—the ACEPHALA—have generally been considered as hermaphrodite, analogies are equally in favor of their being diœcious; or like the 3d class, perhaps some species may be hermaphrodite, while in others the sexes may be separate.

If the affirmative of this question be established, some other cause for the occurrence of the two forms of shells must be sought. It would, however, be an anomaly in nature, if one half of the individuals should prove barren and of no use whatever, in a family where she has provided so carefully for the increase and perpetuity of the species.

So prolific indeed are fertile individuals, that they annually produce their young in numbers almost too great to admit of enumeration. Mr. Lea calculated the oviducts of an *Anodonta undulata,* to contain 600,000 young shells. This, it will be recollected, is a small species, and does not produce a tithe of the young contained in a prolific *Anodonta plana.*

The barren members of a colony of honey bees, (the *Apis mellifica,*) might, at first view, seem to afford an analogy, but they subserve an useful purpose. On the products of their labor, are sustained all the members of their community. If the barren mollusca do not fulfil the purposes of the male, it is difficult to discover of what use they are in creation.

It may be proper to state a fact in regard to habits of the *U. gibbosus* of Raf., and its allied species, the *Unio rangianus* of Lea, which may have some connection with the subject before us. During the months of April or May, according to the state of water in the streams, and warmth of the weather, the females may be seen lying

upon their beaks on gravelly ripples, with their heads directed up stream, and the valves of their shells expanded to their utmost capacity. At this time they are heavy with their young. The pure whiteness of their bodies and appendages renders them conspicuous objects, seen through the limpid water; and their position and appearance would lead to the conclusion that they were dead, and the valves were expanding as their transverse muscles were relaxed. An attempt at taking a specimen into the hand, will at once show that it still abounds in vitality.

The object of assuming this position at this particular period of the year, I could never discover, but suspect it to have some connection with the process of fecundation. In the immediate vicinity are always found more or less males, but as their shells remain closed, they are not so readily recognized.

The female, *U. ventricosus* and *fasciolus*, may sometimes be seen throwing out of their shells the prolongations of their mantles, and playing them about the water, during clear and warm days in autumn. At the same time, male individuals may always be found very contiguous, and it has often been observed by collectors, that at this season, these species seem to be associated in pairs. This portion of their anatomical structure is beautifully illustrated by Mr. Lea, in the Trans. of the Amer. Philos. Soc., vol. 6, Plate XV.

In one instance I saw a female of the *U. cariosus*, throwing out these processes in the Juniata river. The object of this movement we can only infer.

On several occasions I have seen the females of various species of these mollusca, discharging their young progeny. At that period of existence they are perfectly formed shells, as may be discovered by the naked eye, if they are placed in the sun for an hour; or by the aid of a microscope when first obtained.

They are agglutinated together with a secretion, probably of mucus and albumen; and the mass conforms to the shape and size of the branchial cell. The contents of one cell are thrown off at a time, by a jet of water, issuing rapidly through a syphon or contracted aperture, formed by the posterior margins of the mantle.

The mass, on being evacuated falls upon the bottom of the stream, and soon begins to crumble in pieces by the action of the water and collision of the sand, till at length each minute individual becomes free and is left to take charge of itself. It then begins to exert volitions for its own safety and provision. Many, if not all, of the species,

in this condition, spin from their bodies near the foot, a filament resembling silk, by which they attach themselves to adjacent objects which are fixed and solid, such as shells, sticks and stones. I have frequently seen them anchored to their mothers. This filament is deciduous, and disappears as they advance in age and size. A more full account, with illustrations of this curious provision, may be seen in the Amer. Jour. of Science and Art, vol. xxxvii.

Fleming says, "they want a *byssus*." This filament is certainly very near akin to that appendage of the *Mytilidæ*.

It has been alleged that geologists are sometimes compelled to draw a little on their imaginations, in order to supply time for the accomplishment of all the revolutions, that seem to have taken place in the structure of the earth. Within the memory of individuals now living, the recent vegetable and animal kingdoms of Ohio, have undergone changes almost sufficient to mark a geological period. Numerous species, once abundant, are now very rare, or have become extinct. Other species have in some instances supplied their places. No class has suffered more extensive and fatal changes than our mollusca.

Forty-one years since, when I was first acquainted with this State, every permanent pond, lake and river, abounded with fluviatile bivalves. Ohio, at that day, probably contained a greater number of species, than could be found in the whole world, North America excepted.

With the clearing and cultivation of our lands, many disappeared; the depredations of swine during low stages of water, have destroyed immense numbers; the wash of cities, manufactories, and barn yards, are still more fatal to them; and in several instances, epidemics have extirpated immense numbers.

After the construction of our canals, many of the rarer species rapidly increased for a few years, and our conchologists flattered themselves that these thoroughfares would preserve their favorites; but experience has shown that the accumulation of filth in the canals, is fatal to most of the species. A few, especially Anodontas and Alasmodontas continue to thrive and increase, while the finer species of Uniones have perished.

Ten years since, the *Unio truncatus* of Raf. and *cornutus* of Barnes, were common in the canal near Cleveland. At this time a living specimen can hardly be found.

During the present season we have seen workmen excavating portions of mud, that contain great numbers of dead shells of these and other scarce species. Perhaps in another age, similar operations may

expose to view similar remains, which may puzzle the geologist to tell at what period they existed.

At 10 o'clock, the general business of the Association commenced, and the minutes of the meeting of the Standing Committee were read.

The following communication from Professor E. Emmons, to the Local Secretary, was presented to the Association.

Albany, April 3, 1851.

Sir: Allow me to express my regret that I am unable to participate in the doings of the meeting at your place, during its session. My engagements at William's College are such as to detain me; I am thereby deprived of the pleasure of meeting my associates in science, which I regard not only as a pleasure, but a privilege of the highest order. I will avail myself of this opportunity, however, to lay before the appropriate section a very few common-place remarks, respecting a class of inquiries which have forced themselves upon my attention, in consequence of my connection with the Agricultural Survey in the State of New York. It is in regard to that class of bodies which are termed aliments. The popular doctrine of the day is, that these bodies sustain or nourish the animal system, in a ratio proportionate to the amount of nitrogen they contain; and that their value as nutrients may be expressed by numbers. This view of the subject, however, I have never been able to understand, and have never adopted it; for it appears to me that there are other bodies in combination in all these nutrients, which are equally important with nitrogen, and which minister also to the support of the animal system. I shall not attempt to state in detail the objections to the doctrine that the value of nutrients is determined by the amount of nitrogen which they contain. I am satisfied with saying now, that the inorganic bodies, the salts of lime, (particularly the phosphates of that, as well as the other combinations of phosphoric acid,) must be of equal value with the nitrogenous compounds. In the analysis of many vegetable bodies, including the cryptogami, these inorganic bodies are invariably present. They are important, then, in the lowest as well as the highest forms of vegetable life, and more abundant in the class of nutrients, than in those which are not reckoned as such.

But there is still another class of bodies, which are neither poisons nor aliments—indeed, seem to be far removed from both of these classes of bodies, and yet their influence upon the system is salutary,

especially if taken with the proper nutrients. In combination with the nutrients or aliments, the amount of the latter need not be so large, in order to perform a specific amount of work. These bodies may include the milder class of astringents, or I may say more correctly, that they are allied to them. In recoveries from sickness, when the system is reduced, those mild medicines which are denominated tonics, sustain the body more than can be accounted for by the common hypotheses which have been invented to explain their effects. Perhaps one of the most common bodies in use, will illustrate more perfectly my views. Tea, for example, is often used in large quantities. Individuals who become accustomed to this beverage, take comparatively little food, and yet perform as large an amount of work, as if they had taken a full ration of nutrient proper. Opium-eaters consume but little food. Inebriates take but little food for weeks, and sometimes perform considerable work. Now, in order to obtain data upon which it will be safe to found correct views of the office of food and beverages, as well as some of the milder forms of medicines called tonics, it will be necessary to collect a larger stock of facts, and institute many additional experiments. Those inquiries should be made which have reference to the *eremacausis* which the system suffers under exercise and work, whether mental or physical—the direct influence, too, of the bodies which are called aliments or nutrients, in repairing the waste of the system; or, whether it is absolutely true that the system undergoes eremecausis necessarily in labor, mental or physical. So inquiries may be directed to a supposed class of bodies, which do not furnish nutrient matter, and yet do something in its place. Do they prevent waste, or, in other words, save it from waste? If so, may they be denominated *soterifics*, a word coined from the Greek, *savior*. Probably there are many persons who would object to the word *saviors*, when applied to *tea, coffee, porter, spirits, opium*, etc., still science must make her inquiries without prejudice, and if there is a class of bodies which save the system from waste, they may well be denominated, for aught I see, *saviors*. We have, without doubt, calorifics, purely so; and it is a class of bodies essential to the system, though by no means nutrients, in any sense of the word. We often see the system waste rapidly in *diabetis*, and observation supplies us with strong facts, which go to show that the system is sustained with a small amount only of the nutrients, and is capable of performing a larger amount of work, when aided in some way or other by certain beverages. Yours, E. EMMONS.

In view of the importance of closing the meeting of the Association on Friday, it was determined that no additional titles of papers for presentation, be registered.

A communication was presented from the Rev. ROBERT MORRIS, of Jackson, Mississippi, mentioning the fact that the Legislature of that State had passed an act, with reference to a Geological and Agricultural Survey of Mississippi. The act appropriates $3000 per annum, for an indefinite period of time, to support a geological professor and assistant at the State University, located at Oxford. One half of the sum above mentioned is to be drawn from the State Treasury, the remainder from the ample University fund. It is also required that at least one half of the sum specified, shall be expended in a Geological and Agricultural Survey of the State, giving to each county its due share of attention.

The following papers were then presented:

2. REPORT OF THE COMMITTEE APPOINTED TO MEMORIALIZE THE LEGISLATURE OF PENNSYLVANIA, IN REFERENCE TO THE PUBLICATION OF THE FINAL GEOLOGICAL REPORT OF THAT STATE. By SOLOMON W. ROBERTS, Civil Engineer.

THE Committee appointed to "memorialize the Legislature of Pennsylvania, in reference to the publication of the Final Geological Report of that State," respectfully

Report, That the important object contemplated in their appointment has been so far accomplished, that an act was passed by the Legislature of Pennsylvania at its late session, and approved by the Governor, authorizing the publication of the Final Geological Report, in a style worthy of the scientific importance of the subject, and the geological wealth of Pennsylvania.

It contemplates an expenditure of thirty-two thousand dollars for the purpose, and the work is to be done under the superintendence of Professor Henry D. Rogers, the able geologist by whom the survey was made.

The passage of the act is in a great measure due to the efforts of Thos. J. Bigham, Esqr., of Pittsburgh, the member of the Legislature having charge of the bill. The Chairman of the Committee appointed by the American Association, having gone to Europe, the

undersigned Reporter, whose name stood second on the list of the Committee, communicated to Mr. Bigham during the session of the Legislature, the views and wishes of the Association, in reference to the object which has thus been accomplished.

Respectfully submitted on behalf of the Committtee,

SOLOMON W. ROBERTS.

On motion, the report was received, and the Committee discharged.

Prof. HALL expressed his gratification at the success of the application to the State of Pennsylvania, and offered a resolution with reference to the appointment of a committee, to memorialize the Legislature of Ohio, for a similar purpose.

Dr. H. KING requested Prof. Hall to amend his resolution, so as to refer the matter to the Standing Committee, with a view of including the States of Missouri and Arkansas.

Prof. SCHÆFFER made a similar appeal in reference to Kentucky, and gave an illustration, showing the importance of an accurate knowledge of the geology of the States.

After additional remarks by Prof. HALL and others, the subject was referred to the Standing Commmittee.

3. NOTES ON THE SURVEY OF THE BOUNDARY LINE BETWEEN MEXICO AND THE UNITED STATES. By Maj. WM, H. EMORY, late Astronomer to the Commission, and acting Commissioner.

THE object of this paper is to submit to the Association a brief outline of the plan proposed for prosecuting the Survey of the Boundary between the United States and Mexico, and to give a sketch of the results of the operations while the work was under my direction.

Operations involving scientific attainments, carried on by governments, do not always express the condition of scientific knowledge and skill of the country, yet the results are considered abroad, and in future generations, as fair exponents of the state of science which existed at the time in the nation.

In this view, works of a national character may be presumed to form subjects of such interest to the American Association, as to engage its serious consideration.

It is not to be doubted, that when the strength of the men of science in this country, is combined and brought to bear on this subject, the extraneous influences which occasionally embarrass public undertak-

ings, and divert them from their legitimate objects, will be diminished, if not removed altogether.

It is no part of my design to display, at this time, the movement which impelled me to demand my recall from the work, in the latter part of the year 1849; but the occasion is taken to discharge the more agreeable office of stating that the present able and enlightened head of the Department of the Interior, the Hon. A. H. H. Stuart, under whose charge the work is, has evinced on all occasions, the determination to place the work, in all its various branches, upon the most substantial and scientific basis, and has so far approved my plans and results, as to request my recall to the charge of the Survey, in October. 1850.

The boundary, as is well known, extends aeross the continent, from the mouth of the Del Norte to the Pacific—from ocean to ocean—traversing a country much of it unexplored, and abounding in objects of interest.

The instructions given me, while in charge of the Commisssion, contemplated the work to be pushed from the mouth of the Gila, eastward. Believing such a course would end in failure, if not in disaster, I communicated my reasons for so thinking, and recommended a contrary course, which was in the end adopted by the Government. My views on this subject contain observations on the physical character of the country, but as they have already been published by Congress, are not repeated here.

Although, in the progress of the Survey, many suggestions and modifications of the plan would have occurred, yet, as the matter has been much discussed, and was in conflict with the notes furnished for my guidance by the then Secretary of the Interior, it is deemed proper to give it as embodied in the dispatches to the Department, penned in the field.

I quote from my dispatch, dated June 30th, 1850.

"The Survey, which is vast in extent, must be based upon and bound together by astronomical determinations; and therefore the leading subject of attention comes under the head of

Astronomy.

The plan reiterated by me in a letter to the late Commissioner, dated Panama, May 7th, 1849, is that which I still consider best; and

under the circumstances, the only practicable one. It received the full approbation of the illustrious late Secretary of State, James Buchanan.

The whole extent of the boundary between the United States and Mexico, to be marked and delineated on paper, is some three or four thousand miles. The most rigid mode of operating would be to cover the whole ground by triangulation; but the expense and the time required by this method, exclude it from consideration. The next method in order of accuracy, and that which presents itself as the only practicable one, is to base the entire work on astronomical determinations of latitude, longtitude and azimuth. The points for the determination of latitude and longtitude necessary to be established under this system, may for convenience be classed into primary and secondary. The primary should be five in number, and distributed at convenient intervals over the whole line; and the observations at them should as far as possible be carried on simultaneously. These points are, the mouth of the Rio del Norte, El Paso del Norte, the point where the line strikes the affluent of the Gila, the mouth of the Gila, and the initial point of boundary on the Pacific. At the two extreme observatories, that near San Diego, and that at the Boca del Norte, observations should be carried on throughout the whole duration of the work. This would give force and unity to all our results, and render us independent of simultaneous or corresponding observations in Europe.

The secondary astronomical stations will be determined with such portable instruments as can be carried with the Commission, as it progresses in the work of marking the boundary, and will be checked by comparison with the nearest of the five primary stations.

The most prominent portion of the duty assigned me, is the determination of the astronomical lines. The principal one of these lines, immediately depending upon two of the proposed primary stations, and resulting from the observations at them, is the line from near San Diego to the mouth of the Gila river. That to be agreed upon as the western boundary of New Mexico, is dependent upon contingencies that may not arise, and therefore, for the present may be left out of view, in submitting a plan of organization.

It may be proper to say, that soon after receiving my first order, dated December, 1849, to report to the Secretary of State, I submitted by his direction a plan for the organization, a copy of which is not with me. That plan looked to operating entirely from the Atlantic side, except so far as was necessary to fulfill the conditions of the treaty by assembling the Commission at San Diego, and sending over

an astronomical force sufficient to run the line between San Diego and the mouth of the Gila.

"Topography and Demarcation of the Line of Boundary on the Face of the Earth.

"Connected with and dependent on the astronomical work, is the topography and demarcation of the line on the face of the earth; this is naturally divided into four parts, viz.: 1st. That from the initial point on the Pacific, to the junction of the Gila and Colorado. 2d. The boundary between the point of departure from the Rio del Norte to the branch of the Gila designated in the treaty. 3d. This branch or tributary, and the Gila in its whole course, from the junction of this affluent to its mouth. 4th. The Del Norte, from the point to be agreed upon as the initial point of the boundary, to its mouth.

"Each of these divisions, different in character, requires specific instructions for conducting the survey, adapted to their peculiarities, but those which have been already given, and which I propose to extend, embrace some instructions of a general character, which may be briefly enumerated:

"1st. All determinations of the line of actual boundary, and the topography for one mile on each side, must be based on actual measurement.

"2d. As each party will have to work under cover of an escort, there will be at times many persons disposable in camp; these must be employed in exploration, and sketches of the adjacent country.

"3d. Each of the surveying parties is required to make barometric levelings of the section surveyed, and note the general character of the country, in its applicability to agriculture, roads and navigation.

"4th. Each party is required to keep a meteorological record, made up from observations with such instruments as are of a portable kind; constant comparisons being required with kindred instruments at the stationary camps or observatories proposed, at the beginning and termination of each of the four sections of the work.

"Terrestrial Magnetism.

"It is proposed to establish at each of the observatories at the extremity of the line, *magnetometers*, for the measurement of the absolute value of the earth's magnetic force at these two points, and to

obtain the relative measurements of the magnetic force, by the passage of Mr. Fox's apparatus over the whole line, as has been already done under my direction over the first division.

"GEOLOGY, MINERALOGY AND BOTANY.

"When acting as chief astronomer of the Commission, I stepped out of my way to urge the necessity of attention to these subjects, in consequence of the reputed mineral wealth of the country to be traversed, and its rich botanical stores. No attention was paid to the request, but happily one of my assistants was eminently qualified for this service, and I took the responsibility to relieve him from his duties as computer, and allow him to devote his whole time to the subject. The first division of the work may be considered as covered by him.

"Subsequent authority placing me in temporary charge of the Commission, authorized me to assign these branches to this gentleman exclusively; but the magnitude and importance of the subject, prompts me to recommend its division. The geology and mineralogy will be quite sufficient for one person, and the botany and zoology for another.

"The letter of instructions given by me to Dr. Parry, embraces the subjects to which I have most particularly directed his attention; including a manuscript copy of memoranda, furnished by my learned and excellent friend, Dr. Engelmann, of St. Louis.

"A box containing duplicate specimens of all the collections made on the first division, has already been forwarded by Lieutenant A. W. Whipple to Dr. Torrey, under whose able counsel and assistance, Dr. Parry is instructed to prepare and collate his work, when his labors in the field shall have closed.

"ETHNOLOGY.

"The physical and social character and language of the Indian nations also forms a subject of attention; but this will be pastime for the different parties in the field, and the subject need not be confined to any particular individual."

Now I proceeded so far in the prosecution of the work here projected, as to establish the great astronomical line, forming the boundary between the United States and Mexico, from the initial point on the Pacific, to the junction of the Gila and Colorado, and to acquire

the data for presenting what it is hoped may be a fair exhibition of the physical character of the country traversed by this line, and the region for many miles on either side.

It will not come within the scope of this paper, to expose the difficulties which were interposed in the prosecution of the work, owing to the fact that no part of the liberal appropriations voted by Congress for this work, were sent me from the day I landed on the Pacific, June 2d, 1849, until after the accession of the new Secretary of the Interior, when I had already commenced to retrace my steps homeward, in the fall of 1850.

Nor is it my purpose to note the great embarrassment caused by the extraordinary condition of things in California, by which the wages of the most indifferent laborer or attendant, were suddenly raised from thirty dollars a month to one hundred and fifty. It is, however, but fair to bear them in mind, in presenting a summary of what was accomplished.

By the terms of the treaty of Guadaloupe Hidalgo, the portion of the boundary above referred to, commenced at a point one marine league south of the port of San Diego, and ran thence in a straight line to the junction of the Gila and Colorado rivers, a distance now ascertained to be 148 miles and some feet.

The intervening country is of that character, which renders experimental lines or trigonometric surveys impracticable, except at an enormous expenditure of time and money. Rising from the ocean in steppes, of hights respectively of 400, 3000 and 5000 feet, above the sea, at the distance of about sixty miles, the land falls abruptly into the great basin, forming the desert at the head of the Gulf of California, and throughout this whole extent, is destitute of water to drink, and for much the largest portion of the way, of herbage sufficient to subsist animals.

I therefore concluded to determine the line astronomically, by ascertaining the difference in latitude and longitude of its extremities, and deducing therefrom the azimuth of the line connecting them.

For this purpose I established early in July, an observatory at the nearest convenient place to the initial point on the Pacific, and named it Camp Riley, in honor of the general who did much to forward my operations. Another observatory was established by my order, at the other extremity of the line, at the junction of the Gila and Colorado. This last was in the heart of a treacherous Indian nation, yet unsub-

dued. The outfit therefore was made with a view to defense. Owing to the withholding of supplies, the change in the Commissioner, and the failure in the new Commissioner to show himself then or thereafter, I was obliged to make the outfit on my own responsibility, and the observatory was not in operation until late in September.

The observations at Camp Riley were conducted by me in person; those at the other observatory by Lieut. Whipple.

At both observatories was an ample supply of good chronometers, furnished by the Messrs. Bond, of Boston. At the first, was a zenith telescope, of forty-six inch focal length, an astronomical telescope, and a transit instrument of the same focal length; at the last, a thirty-six inch transit, and forty-six inch zenith telescope, all by Troughton and Semmes, of London.

My previous reconnoissance showed the difference of latitude not to exceed fifteen minutes; and my aim was to use the same pairs of stars for the determination of latitude, and to get simultaneous observations on the culminations of the moon, and the moon-culminating stars, so as to avoid the errors in the tabular places of the stars.

As soon as I was notified, by express, of the establishment of the observatory at the mouth of the Gila, Captain Hardcastle was despatched, with parties, to occupy three different peaks in the direction of the line, Cerro Colorado, Los Pinos, and Mount Wiccarnon, which a previous reconnoissance had indicated as proper points from which to make signals, by discharging rockets and flashes of gunpowder.

Counting the stations, including the observatories, from west toward the east, and numbering them 1 to 5, it was believed that flashes could be seen from 1 to 2, from 4 to 5, and from 3 to both 2 and 4. Having the local time of flash at 2 observed from 1, the difference between the flash at 2 and the flash at 4, observed from 3, and the local time of the flash at 4, observed from 5, the difference in local time between 1 and 5 is given, and, consequently, the difference of longitude.

Captain Hardcastle, and his party, directed these flashes for five nights in succession, and on one of the nights the chain of observations was complete as far as 4; but the observers at 5 failed to see a single flash from No. 4, owing to fogs which, at that season, drift in at night from the head of the Gulf of California, and obstruct the view across the southern part of the Desert. No means were allowed to enable me to persevere in this design, which would have given me the difference in longitude, with nearly the same accuracy as a geodetic opera-

tion, and certainly as good as the telegraphic wire; and I was obliged to rely upon the differences deduced by observations on the heavenly bodies. As it happens, these are satisfactory enough.

The observations for latitude, at Camp Riley, are given in Appendix. They were made, as before stated, with the zenith telescope, of forty-six inch focal length, and after the method known to American astronomers as Talcott's method. Now it should be stated, that these observations, satisfactory as they are, were made with an instrument constructed so far back as 1836, and which has been much used, and contains none of the improvements adopted in those of the Coast Survey, some of which I had the honor of suggesting, in 1846.

It will be seen, that the general result is based upon upward of four hundred observations, and that there are one hundred and ninety independent results obtained from observations on eighty-two different stars. The stars were used in pairs, and the latitude obtained by giving to each pair a weight depending on the number of observations, is 32° 35′ 43″ 54.

The general mean of each night is 32° 35′ 45″.73
Of each pair, – – 43″.56
And of all, – – 43″.53, and the probable error from a single pair is 1″.48, and the limit of the probable error from all the pairs is only 0″.198. Much depended on the correctness of the latitudes; hence the number of observations.

The differences of longitude at the two observatories were obtained by observations on every culmination of the moon visible at Camp Riley, from the 1st August to 1st December, 1849, in number 26, and at the other end from 1st September to 30th November, in number 30. But one occultation was observed,—that of Aldebaran, at Camp Riley,—owing to the very extraordinary condition of the atmosphere, and the fogs which at that point, in that region, envelop the coast nearly every night of the summer months.

The differences of longitude were deduced in the field, and, with the latitudes, were transferred, by geodetic methods, to the extremities of the line. At the Gila, the observatory was within a few hundred yards, but my observatory was between seven and eight thousand metres from the initial point of the boundary, and the transfer was made by a triangle, with a base of 4536.69 meters. The base was measured twice, with great care, by rods made of seasoned red wood and steel wires, graduated from a meter, measured by Gambey, of Paris. The angles were measured with an Ertel theodolite, eighteen inches in diameter.

Owing to the great motion in the atmosphere, caused by the cold currents of air, from the sea passing over the heated and parched surface of the earth,—which, at the time I speak of, had not received a drop of rain for five months,—I was two months in measuring the angles of this triangle satisfactorily, and transferring to the boundary the azimuth of one of its sides, determined by a series of observations at the observatory.

I would, therefore, suggest to those who propose geodetic operations in that region, to conduct them in what is called the rainy season; that is, from December to March. The temperature, then, is delightful; the atmosphere, at times, very clear, and the falling of rain not more frequent than in the summer time on the coast of Maine. Occasion was taken to transfer, by angulation, my determination of the geographical position of the observatory, to Punta Loma, the headland forming the northern cape of the entrance to the bay and port of San Diego. This result, so interesting to mariners, has been applied for very often, and I avail myself of this opportunity to communicate it:

Latitude of Punta Loma,	32° 39′ 30″.6s
Longitude of do., west from Greenwich,	7h. 49m. 0.48s.

Throughout the whole campaign, a series of magnetic, barometric, and hygrometric observations were kept up at the principal stations; and portable instruments were sent with every reconnoitering party, so that a complete series has been obtained throughout the whole extent of the line. From the barometric notes, it will be practicable to obtain a profile of the country.

The geological and botanical survey of this region was conducted by Dr. C. C. Parry. He is now engaged with Dr. Torrey in bringing out his results.

The Reptilia, and other animals of the country, did not receive that attention from the commission which the subject deserves, from the fact that the proper facilities were not afforded, and from the circumstance that a very intelligent and zealous young naturalist,—Dr. Le-Conte, of New York,—was present; who, although he held no official position on the work, was much associated with the Commission, and came out for the express purpose of obtaining that kind of information. No formal agreement existed between himself and Dr. Parry, yet a tacit understanding prevented each from interference in the special pursuits of the other.

The region covered in our operations is not very extended; but, from its position and novel character, of much interest. Little was known of it, except from a military reconnoissance, conducted by myself in a rapid march, made with the troops in the fall of 1846; it is therefore hoped and believed that Government will grant the means to complete the office work of what has now been accomplished in the field.

The region embraces the delta of two remarkable rivers, the Colorado of the West and the Gila. The first, reaching many thousand miles into the interior, resembles, in some of its leading features, the Nile, more than any other river on this continent. Its debouche from the mountains into the desert, is less imposing than might be supposed from the vast extent of the region which it drains. At that point, in low stages of the water, it is not more than six hundred feet wide, and from six to twenty feet deep, and passes at the rate of about three miles the hour. It is charged with a sediment giving the water a reddish tinge; and from this circumstance derives its name Colorado, (Red.) The season of greatest freshets at the junction of the two rivers, is during the months of July and August, caused by the melting of the snows in the regions of the far distant and northern sources of the Colorado. Then the ground for many miles on either side, is overflowed and fertilized, and the Indians retire to the hills with all the demonstrations of joy which the people of the Nile exhibit on such occasions. They see in that the guaranty of a plentiful harvest. The moment the waters recede, is the time for planting corn, melons, and beans. These grow and come to maturity with surprising rapidity, so that the harvest season is in the latter part of October and the first of November. I have not the least doubt that by planting in March, and resorting to irrigation, a crop could be raised and harvested before the overflow in July, and thus two crops be raised every year.

The distance the river is navigable above the junction, is yet unknown; it is now ascertained to be navigable for small steamers to its mouth. Gold has been found above the junction, about where the range of mountains containing auriferous quartz should strike, which have already been traced, in a distinct line, as far south as the parallel of Los Angelos.

Notwithstanding the forbidding aspect and sterile character of the table land on both sides of this great river, and the fact that, with exception of the military camp, not one white man is settled on it, the region under discussion is destined to make an important figure in the

social and political world, from its salubrious climate, the fact that all auriferous veins discovered in California are directed toward it, and are every day being brought nearer to it, that it presents the only outlet to the immense extent of country drained by the Colorado and its tributaries; and, above all, that it is in my opinion the only region through which it is practicable to connect, by railway, the two sides of our country, by communication lying within or contiguous to our territory.

From a careful examination of all the explorations made in the more northern regions, with those made along the line which I shall presently sketch, a large portion of which last was made by myself, the impression is fixed, which I have, on more occasions than one, expressed in official communications to the Government, that if a railway to the Pacific, within our own territory, is seriously contemplated, a passage exists near the thirty-second parallel of latitude, by which snows are entirely avoided, and where no elevation requiring tunneling or stationary power, will have to be resorted to.

This line may commence any where on the Mississippi or Missouri, from Independence to the Gulf; but it must, before it reaches the Rocky Mountain chain, deflect sufficiently far to the south to turn the Guadaloupe Mountains, which terminate on an elevated plain in Texas, about the parallel of 31°; there it will follow any of the various passes explored by Colonel Johnstone, of the Topographical Engineers, and Captain Marcy, of the United States Infantry. Crossing the Del Norte about El Paso, it will follow a direction not far from the thirty-second parallel of latitude until it strikes the emigrant trail from Chihuahua; thence it will follow that trail, by easy descents, some one hundred and thirty miles, to the valley of the Gila river. The line will then pass along that river, without obstacle, to the junction of the Gila and the Colorado, where Nature has made the abutments for a passage, far above the reach of floods, in the huge Feldspathic-granite portals through which these rivers pass at the moment of uniting. From this point three practicable lines present themselves, any of which may be chosen; and the choice will undoubtedly be made by the preponderating commercial influence which exists at the time, viz:

First: A line to the Gulf of California or the Sea of Cortez. Second: Across the mountains to San Diego. Third: By the valley of the Tulare Lakes and the San Joaquin, to the valley of the waters of San Francisco Bay.

4. On the Effects of the Areas of Oceanic Temperatures. By Capt. Charles Wilkes.

(*Not received.*)

5. Geographical Distribution of Certain Species of Fluviatile and Terrestrial Shells. By J. S. Newberry, M. D., Cleveland, O.

(*Abstract.*)

Congress Lake, a small body of water, lying on the south line of the Western Reserve, between Portage and Stark counties, besides other shells common to most of the lakes in northern Ohio, contains four species which may be called rare. These are,

Limnea gracilis, *Melania gracilis*,
L. jugularis *Ancylus fuscus*.

Of these, *Limnia gracilis* is found only in one other locality, and that is, Lake Champlain, where it was discovered by Prof. Adams; and until I obtained it from the above mentioned locality, it was supposed to be confined to its eastern habitat.

Limnea jugularis—the analogue of the European *L. stagnalis*, and the largest of our fresh water univalves—is found no nearer, and I believe in no other locality, than some points on the upper great lakes.

Melania gracilis, like the Limneas, of which I have spoken, a peculiar and beautiful shell, is confined to Congress lake and another near by—a singular fact in regard to a Melania, a genus generally inhabiting only running streams. This species was described by Mr. Anthony, from specimens from this locality.

The fourth shell—*Ancylus fuscus*—like *Limnea gracilis*, is found in Vermont. I am not aware that it has been discovered in the interspace.

I ought also to state in this connection, that the country about Congress lake furnishes at least two other shells—*Helix diodonta* and *H. multidentata*—which are found in Vermont, and as yet not elsewhere.

I have examined the other productions of Congress lake—its plants, fishes, etc., but have detected nothing peculiar to it in either of these departments.

The general features of the lake and surrounding scenery, are not such as to distinguish it from those which lie about it, and which do not contain its peculiar shells.

It is situated, geographically, on the ridge or table land which divides the waters flowing north, from those which run south into the Ohio, at an elevation of about five hundred feet above, and at a distance of forty-five miles south from, Lake Erie.

Its geological position is over the out-crop of the lowest stratum of coal in the Ohio coal basin, but the rocks do not appear in the immediate vicinity, being concealed by heavy beds of drift.

By its isolated position, cut off entirely from the ordinary channels of communication—canals and running streams—of which many of our molluscs are so ready to avail themselves when they exist, I have thought the concentration in its waters of several well marked species of shells, whose only other habitats are so remote, was not without interest.

6. On the Longitude of the Cincinnati Observatory, by Telegraphic Operations, in connection with the U. S. Coast Survey. By Prof. O. M. Mitchel, Director of the Cincinnati Observatory.

Prof O. M. Mitchel addressed the Association on the subject of the telegraph operations of the Coast Survey, between Philadelphia and Cincinnati, in 1848, for the purpose of determining their difference of longitude, as follows:

"It is well known to the members of the Association that an astronomer, who wishes to avail himself of the computations of the places of the heavenly bodies, made for observatories of foreign nations, must determine his longtitude from them. In the early commencement of my labors, this was effected with much success, by observing the transit of Mercury, of 1845.

In 1848, the Coast Survey, having need to determine the longitude of New Orleans, and having for this purpose selected the western line of telegraphs, as far as completed, I was invited by Prof. A. D. Bache, Superintendent, to furnish the co-operation of the Cincinnati Observatory. This offer was the more readily accepted, because the junction with the Atlantic stations of the Coast Survey would render available for our use the extensive series of results already in its possession. The junction line from the city to the Cincinnati Observatory, was erected in 1848, and presented by Henry O'Reilly, Esq., to the Observatory. Very liberal arrangements for the work were made by James D. Reid, Esq., General Superintendent of the western O'Reilly telegraph lines.

The general direction of the work was intrusted to Sears C. Walker, Esq., Assistant of the Coast Survey. The peculiar apparatus was furnished by the Coast Survey; and in October, 1848, the work was commenced. I have now before me the full official report of Mr. Walker to the Superintendent of the Coast Survey, giving all the incidents and statistics of the work."

Prof. MITCHEL then read several extracts from Mr. Walker's report, observing the close agreement of the results obtained by the same persons on successive evenings, or on the same evening by different persons or methods. After which he remarked that he should never forget the impression made on him by the night's work on the twelfth of October.

"Every thing being in readiness for the work, a message was received from Prof. E. Otis Kendall, director of the Philadelphia Observatory, and the work proceeded as follows:

Ph.—Are you ready for star signals?
Ci.—Yes.
Ph.—Look out for No. 539, B. A. C.*
Ci.—Yes, all ready.
Ph.—Star is in the field; look out.

Then came, at intervals of about a quarter of a minute, seven distinct signals or magnet beats, which we all heard at the Observatory, and compared with our standard time-keeper. Prof. Kendall had also recorded his magnet beats by the time of his standard clock. These seven signals were the dates of the passage of this star over the meridian spider-lines of his transit instrument. Then followed the conversation:

Ph.—Did you get my star signals?
Ci.—Yes.
Ph.—I will send you three more stars.
Ci.—Ready.

After three more stars had been treated in the same way:

* British Association Catalogue.

Ph.—Did you get the three stars?
Ci.—Yes.
Ph.—Then send me back all four."

Prof. Mitchel here explained that the fourth star had thus been observed at Philadelphia, and recorded at both places, before the first one had reached Cincinnati, when the reverse of the process just dessribed, took place. Cincinnati gave the star signals, and both Cincinnati and Philadelphia recorded them at the same time. The process of computing the longitude from such an experiment, is very simple. The time that elapses on the standard clock, after the star passes the meridian of Philadelphia, and before it reaches Cincinnati, is the difference of longtitude in time. Fifteen times that quantity is the geographical difference of longitude in arc.

Prof. Mitchel then handed to the Secretary, for publication, the official report of Mr. Walker to the Superintendent of the Coast Survey.

Washington, April 4, 1851.

To Prof. A. D. Bache, LL. D., Sup't Coast Survey:

Dear Sir—I beg to submit my final Report on the work of October, 1848, for determining the longitude of the Cincinnati Observatory, from that of the Central High School of Philadelphia.

The Philadelphia operations were under the charge of Prof. Kendall, assisted by Mr. Mason, and Mr. Reynolds.

The Cincinnati operations were under the charge of Prof. O. M. Mitchel, Director of the Observatory, and his Assistants, Messrs. Twitchell and Trask, and Prof. Yarnall, U. S. N. The general direction of the work was under my charge, with the assistance of Mr. L. F. de Pourtalés.

The outfit of the Philadelphia Station consisted of the clock and transit instrument of that establishment; one solar chronometer, 2495, Parkinson and Frodsham; and the Morse recording apparatus, belonging to the Coast Survey.

The outfit of the Cincinnati Observatory consisted of one of the two five-foot transit instruments, made for the Coast Survey by Troughton, in 1816. To this was added a Morse recording apparatus, belonging to the Survey. The time-keepers used were, the solar chronometer,

No. 310, Tobias, belonging to the High School Observatory, (loaned to the Coast Survey by Prof. Kendall); a sidereal chronometer, No. 744, Parkinson and Frodsham, belonging to Prof. Mitchel; two solar pocket chronometers, No. 190, Lukens, belonging to myself, and No. 66, Hourier, belonging to Pourtalès. On the night of the 26th of October, we used, in addition to these, the chronometer No. 2039, Molyneux, loaned to us by Dr. John Locke.

The nights of successful work were, the 7th, 9th, 12th, 14th, 20th, and 26th of October, when clock signals, received by the ear, were exchanged between the two stations. Star signals were also exchanged, on all but the 9th.

The comparisons of chronometers were made at each station by coincidences of beats. The exchange of clock signals was conducted in the same manner. To identify hours, minutes, and seconds, one minute was signalised from each station, by signals, each ten seconds apart. The Philadelphia signals, every second, for coincidences, were given by Prof. Kendall, on the Lukens sidereal clock. They were received, at Philadelphia, on the solar chronometer, 2495, by coincidences of beats, in duplicate, by Mr. Mason and Mr. Reynolds. They were received, at Cincinnati, by coincidences on the solar chronometer, 310, Tobias, by Prof. Mitchel, Pourtalès, Twitchell, Trask, Yarnall, and myself.

The Cincinnati second signals were given by myself on the 7th of October, and, on the other nights, by Prof. Mitchel. They were received, at Philadelphia, on the Lukens sidereal clock, by Prof. Kendall, Mr. Mason, and Mr. Reynolds, by coincidences of beats.

The equatorial reduction of each of the seven wires of the Extel transit instrument, at Philadelphia, to the mean of the seven, was as follows. The arrangement is for lamp west:

	s
A to mean of seven	+ 31.967
B	+ 21.334
C	+ 10.836
D	+ 0.033
E	— 10.718
F	— 21.423
G	— 32.030

For the Troughton transit instrument, at Cincinnati, these values were—

	s
A to mean of five	+50.085
B	+25.090
C	— 0.036
D	—25.059
E	—50.080

The corrections of the clock readings for the observed time of the transit of a star over a wire, as registered by the use of the eye and ear, are as follows:

	AT	Weight in No. of wire.
	s	
For Walker,	—0.026	470
Kendall,	+0.072	1003
Mason,	+0.054	482
Reynolds,	—0.093	445
Mitchel,	—0.050	172
Pourtalés,	—0.289	165
Yarnall,	—0.033	244
Twitchell,	—0.217	122
Trask,	—0.129	90
Wm. Cranch Bond,	+0.000	840

The corrections n and c, of the polar and collimating deviations of the mean of the wires for lamp West, in the two transit instruments, were as follows:

	At Philadelphia.		At Cincinnati.	
	s	s	s	s
1848, Oct. 6,	$n=$ —0.306	$c=$ —0.128	$n=$ —0.237	$c=$ —0.299
7,	—0.090	"	"	"
8,	0.035	"	"	"
9,	+0.020	"	"	"
10,	"	"	—0.215	—0.290
11,	—0.785	"	"	"
12,	—0.162	"	"	"
13,	"	"	"	"
14,	—0.082	"	"	"

	At Philadelphia.		At Cincinnati.	
	s	s	s	s
1848, Oct. 15,	$n=-0.082$	$c=-0.128$	$n=-0.215$	$c=-0.290$
16,	"	"	"	"
17,	"	"	"	"
18,	"	"	"	"
19,	—0.403	"	"	"
20,	—0.293	"	"	"
21,	"	"	"	"
22,	"	"	"	"
23,	"	"	"	"
24,	"	"	"	"
25,	+0.257	"	"	"
26,	+0.137	"	—0.948	—0.810
27,	+0.179	"	"	"
28,	—0.219	"	"	"
29,	"	"	"	"
30,	—0.331	"	"	"

After correcting the times of transit for the observed bias of the axis, let ω = the clock correction, neglecting m, u, and c; then $\Omega=\omega+(M-N)n-Cc$ = the actual clock correction, in which, M = Nat. Tan. latitude, N = Nat. Tan. declination, and C = Nat. Secant declination.

The correction of the Lukens sidereal clock at Philadelphia, on sidereal time, was as follows, at 24h. siderial time, the personal equations being applied.

Date 24h. Sid. Time, Phila.	Lukens Sid. Clock. Ω	Sid. Rate. r
	s	s
1848, Oct. 5,	+ 2.304	+2.17
6,	+ 0.116	+2.07
7,	— 1.755	+1.94
9,	— 5.835	+1.97
11,	—10.007	+2.65
12,	—12.876	+2.84
14,	—17.180	+2.25
19,	—30.112	+2.93
20,	—32.918	+2.99

Date 24h. Sid. Time, Phila.	Lukens Sid. Clock. Ω	Sid. Rate. r
	s	s
1848, Oct. 23,	—42.064	+2.64
24,	—44.538	+2.56
25,	—47.192	+2.73
26,	—50.084	+2.86
*27,	+ 7.067	+3.02
28,	+ 4.191	+2.95
30,	— 1.168	+2.53

The following were the corrections of the solar chronometer, 310 Tobias, on mean solar time at Cincinnati, at 24h. siderial time, the personal equations being applied:

Date 24h. Sid. Time, Cin.	Solar 310, Tobias. Ω	Solar Rate. r
	s	s
1848, Oct. 6,	+48.068	—0·30
7,	48.102	0.69
8,	49.450	1.25
9,	50.804	1.51
10,	52.475	1.57
11,	53.742	1.29
12,	55.047	1.25
13,	56.243	0.74
14,	56.531	0.49
17,	59.787	1.44
20,	65.194	1.63
21,	66.760	1.47
22,	67.292	1.31
24,	70.704	0.79
26,	70.466	0.27

The formula in my Coast Survey blank form No. 3, for longitudes by telegraph, is:

$$\text{Concluded longitude} = d = d' \pm (\epsilon - \zeta + \kappa + \theta)$$

* Before observation clock retarded 1m.

Where the upper sign is for eastern signals, and,

d' = the approximate longitude, after applying the corrections for the clock, transit instrument, and personal observing equation.

ε = the correction to d' for personal error in tapping clock signals. This, in conformity with all the experience of the Coast Survey to this time, (1851,) is assumed to be insensible.

ζ = the correction to d', for the personal error in recording telegraph coincidences by the ear. This value is unknown. The ζ here used, is the reduction of each observer's d' to the average value of d', for all the persons at a single station.

$\varkappa$ = Wave time of the galvanic current. In my report for 1850, I have stated this value to be one second for 15,400 miles of iron wire. In the work from Philadelphia to Cincinnati, in 1848, the length of iron wire was, via Pittsburgh, on the O'Reilly line, 674 miles, and the wave time at the above rate, 0.044^s. I have used this value in the computations for this Report.

θ = The time of the armature, traversing the electropœa pass. I have used Dr. Gould's estimate for the value of θ, viz: $\theta = +0.030^s$. We worked with an electropœa key.

The values of ζ for the several observers, in registering coincidences, were as follows:

			s
For Walker,	W.,	$\zeta =$	-0.006
Mitchel,	M.,		-0.002
Pourtalés,	P.,		$+0.025$
Yarnall,	Y.,		$+0.012$
Twitchel,	Tw.,		$+0.005$
Trask,	Tr.,		-0.009
Kendall,	K.,		$+0.009$
Mason,	M.,		$+0.003$
Reynolds,	R.,		-0.012

The following is the reduction of each Cincinnati observer's record of Philadelphia star signals, received and compared by the ear, with the solar chronometer, No. 310, to the mean of the six:

	s
W. to mean of six,	$\Delta T = +0.046$
M.	$+0.096$
R.	-0.008
Y.	$+0.020$
Tw.	-0.106
Tr.	-0.050

And for the three Philadelphia observers:

	s
K. to mean of three,	$\Delta T = -0.032$
M.	-031
R.	$+0.063$

The values of *d*, on the west Longtitude of Cincinnati Observatory, from that of Philadelphia, after the above data, came out as follows:

Date.		Place of Clock Signals.	Signalizer.	Place of Reception.	Receiver.	Concluded Longtitude = *d*.
						m. *s.*
1848.	Oct. 7	Phil'a	Kendall	Cincinnati	Walker	37 20.694
"	"	"	"	"	Mitchel	.693
"	"	Cin'ti	Walker	Philad'a	Kendall	.771
"	"	"	"	"	Mason	.724
"	Oct. 9	Phil'a	Kendall	Cincinnati	Walker	.791
"	"	"	"	"	Mitchel	.795
"	"	"	"	"	Pourtalés	.776
"	"	Cin'ti	Mitchel	Phila'da	Kendall	.722
"	Oct, 12	Phil'a	Kendall	Cincinnati	Walker	.238
"	"	"	"	"	Mitchel	.206
"	"	"	"	"	Pourtalés	.319
"	"	Cin'ti	Mitchel	Philad'a	Kendall	.100
"	"	"	"	"	Mason	.100
"	"	"	"	"	Reynolds	.109
"	Oct. 14	Phil'a	Kendall	Cincinnati	Walker	.420
"	"	"	"	"	Mitchel	.403
"	"	"	"	"	Pourtalés	.953
"	"	"	"	"	Yarnall	.371

Date.		Place of Clock Signals.	Signalizer.	Place of Reception.	Receiver.	Concluded Longtitude = d.
						m. s.
"	"	Cin'ti	Mitchel	Philad'a	Kendall	.360
"	"	"	"	"	Mason	.343
"	"	"	"	"	Reynolds	.325
"	Oct. 20	Phil'a	Kendall	Cincinnati	Walker	.829
"	"	"	"	"	Mitchel	.811
"	"	"	"	"	Pourtalés	.799
"	"	"	"	"	Twitchell	.826
"	"	"	"	"	Trask	.826
"	"	Cin'ti	Mitchel	Philad'a	Kendall	.758
"	"	"	"	"	Mason	.714
"	"	"	"	"	Reynolds	.738
"	Oct. 26	Phil'a	Kendall	Cincinnati	Walker	.786
"	"	"	"	"	Mitchel	.801
"	"	"	"	"	Pourtalés	.775
"	"	"	"	"	Yarnall	.787
"	"	Cin'ti	Mitchel	Philad'a	Mason	.636
"	"	"	"	"	Reynolds	.636

From these data we derive the longitude of Cincinnati, by coincidence of clock signals:

		By eastern clock sig's.	By western clock sig's.
		m. s.	m. s.
1848—Oct.	7,	37 20.694	37 20.747
	9,	.787	.722
	12,	.287	.103
	14,	.397	3.43
	20,	.818	7.37
	26,	.787	6.36
Mean result,		37 20.628	37 20.548
		37 20.548	
Mean, by E. and W.		37 20.588	= longitude, by telegraph coincidences.

The results of the star-signals between the two stations may be divided into four classes:

CLASS I.—Philadelphia star-signals, recorded at both stations, corrected for instrumental deviations; for relative personal receiving equations; for electropœa armature time, and for wave time.

II.—The Cincinnati star-signals, treated in the same manner.

III.—Signals of the same star at both stations, received at Cincinnati, the small corrections being applied.

IV.—The same received at Philadelphia, corrected in the same manner.

RESULTS BY STAR-SIGNALS—CLASS I.

		m. *s.*	*m.* *s.*
1848—Oct. 7,	574	37 20.354	
	625	.417	37 20.485
	684	.685	
Oct. 12,	539	.425	
	574	.295	37 20.301
	625	.121	
	684	.365	
14,	539	.527	
	760	.354	
	794	.501	
	837	.588	
	881	.706	37 20.504
	1202	.451	
	1245	.506	
	1284	.444	
	1309	.459	
20,	648	.494	
	760	.569	
	794	.865	37 20.686
	837	.701	
	881	.800	
26,	648	.644	
	624	.698	
	1090	.492	37 20.655
	1121	.684	
	1148	.759	

RESULTS BY STAR-SIGNALS.—CLASS II.

		m. s.	m. s.
1848—Oct. 12,	539	37 29.226	
	574	.151	37 20.171
	625	.285	
	684	.022	
14,	760	.536	
	837	.536	
	881	.702	
	1202	.422	37 20.500
	1245	.466	
	1284	.336	
	1309	.497	
26,	625	.554	
	648	.485	
	720	.613	
	1090	.481	
	1148	.419	
	1202	.480	37 20.525
	1245	.461	
	1284	.574	
	1309	.585	
	1346	.597	

RESULTS BY STAR-SIGNALS.—CLASS III.

		m. s.	m. s.
1848—Oct. 12,	539	37 20.286	
	574	.374	37 20.307
	625	.392	
	684	.175	
14,	760	.522	
	837	.875	
	881	.548	
	1202	.614	37 20.499
	1245	.086	
	1284	.391	
	1309	20.460	
26,	648	21.031	
	720	20.883	37 20.190
	1090	21.034	
	1148	21.692	

RESULTS BY STAR-SIGNALS—CLASS IV.

		m. s.	m. s.
1848—Oct. 12,	539	37 20.729	
	574	.364	37 20.427
	625	.082	
	684	.534	
14,	760	.158	
	794	.053	
	837	.203	
	881	.476	37 20.333
	1202	.474	
	1245	.499	
	1284	.340	
	1309	.460	
26,	648	.876	
	684	20.534	
	1090	21.049	37 20.722
	1112	20.376	
	1148	20.777	

COLLECTION OF RESULTS.

		m. s.	w'ht
1848—By eastern clock signals six nights,	d=	37 20.638	4
western, " "	d=	37 20.548	4
eastern star-signals, Class I.—5 nights	d=	37 20.526	1
western " " II.—3 "	d=	37 20.398	1
eastern " " III.—3 "	d=	37 20.572	1
western " " IV.—3 "	d=	37 20.494	1
Mean by weights,	=	37 20.558	12

From all these data, I conclude, that the Cincinnati Observatory is west of the Philadelphia Observatory 37m. 20s. 558.

Yours, respectfully,

SEARS C. WALKER,

Asst. U. S. C. Survey.

7. Abstract of an Introduction to the Final Report on the Geological Surveys made in Wisconsin, Iowa, and Minesota, in the years 1847–'48–'49, and '50, containing a Synopsis of the Geological Features of the Country. By D. D. Owen, M. D.

These surveys were made, under instructions from the general government, by Dr. Owen, as principal geologist, by Dr. Norwood, as assistant geologist, and by Dr. Shumard, Dr. Evans, Prof. Litton, Col. Whittlesey, and Mr. B. C. Macy, as heads of sub-corps.

The district of country embraced in these surveys comprises about two hundred thousand square miles, lying both east and west of the Mississippi; partly in Iowa, partly in Wisconsin, and partly in Minesota.

That portion which lies east of the Mississippi is bounded, on the south, by the Wisconsin river, east, by the State of Michigan, and north by the Territory of the Hudson's Bay Company; that portion which lies west of the Mississippi is bounded, on the north, by the Minesota river, and the northern line of Iowa, west, by the Missouri river, and south by the line dividing Iowa and Missouri. The region of country, therefore, over which the surveys have extended, embraces an area at least six times as large as the State of New York.

Throughout this vast district, all the principal streams which water it have been explored, to the number of ninety-one; and more than a fourth of these have actually been navigated, from their mouths to their sources, in bark canoes.

The sections near the confluence of the Mississippi and Wisconsin rivers, are the starting points, by which the connection between the geology of this district, and the one previously surveyed, in 1839, is best understood; at the same time, they serve as standards, by which the geological formations of the Upper Mississippi can be most easily referred to those parts of the west, the geology of which was previously known.

Those who have had an opportunity of consulting the report of 1839 on the Dubuque District of Iowa, and Mineral Point District of Wisconsin, may recollect that the upper of two magnesian limestones of the north-west occupies the greater portion of the surface of those land districts. This upper magnesian limestone only caps the hills north of the Wisconsin river, and very soon runs out, giving place to the underlying sandstones, and lower magnesian limestone, which gradually

emerge from beneath the water-courses; rising, with local undulations higher and higher, as you proceed north, until, finally, the two inferior members,—i. e., the lower magnesian limestone, and lowest sandstones of this protozoic system,—range, exclusively, from within a few miles of the Wisconsin river to beyond the St. Croix, and within a short distance of the mouth of the Minesota, where they again sink beneath the water-courses, and are once more overlaid, by the upper, soft, white, crumbling sandstone, and schistose, fossiliferous limestone of the Falls of St. Anthony; beds which correspond, in age and geological position, to those described in the report of 1839, as intervening between the two above-mentioned magnesian limestone formations of the Wisconsin river, which are contemporaneous with a portion of the Lower Silurian system of Europe.

The average width of surface exposure occupied by the lower magnesian limestone, and lowest sandstones, of the protozoic system of the Upper Mississippi, may be about one hundred miles, one half of which lies on the east side, and one half on the west side of the stream; its boundary line on the east, or rather north-east, being coincident with the principal falls of the streams flowing into the Mississippi in Wisconsin, where the crystalline rocks come to the day. The western confines of the lower magnesian limestone, lie toward the sources of the western tributaries of the Mississippi, where, however, this formation is, to a great extent, concealed by drift and deep recent deposits.

In consequence of the prevalence of the south-western dip of the sedimentary rocks through this country, the lowest beds rise nearest the surface on the north-east; accordingly, here are to be found the lower beds of sandstone, with little or no covering of magnesian limestone, occupying a belt of country from twenty to thirty miles in width, while over the other two-thirds, the sandstones only constitute the base of the sections, having, for the most part, a considerable covering of lower magnesian limestone.

The lower magnesian limestone, and, indeed, to some extent, the sandstones, are metalliferous, yielding both lead and copper. These ores have been mostly found in pockets, or in horizontal openings; at one locality, however, on the Half-breed Tract, below Lake Pepin, a regular east and west vein, apparently several inches in width, was seen traversing the lower magnesian limestone.

The copper is a hydrous di-carbonate, mixed with some silicate of copper, and copper pyrites, similar in quality to that described in the report of 1839, as occurring in the vicinity of Mineral Point, and

yields from ten to twenty per cent. of metallic copper. The lead ore is a sulphuret of the same composition as that occurring in the Dubuque and Mineral Point districts.

On the north-west of the District, the locality where the upper magnesian limestone disappears from the surface beneath the superior strata, is not far from Red Rock, between the mouth of the St. Croix and Carver's Cave; thence the soft white sandstone, and fossiliferous limestones, which crown the hills near the mouth of the Wisconsin, again set in, and constitute the sections below St. Paul's, at Carver's Cave, Fort Snelling, and the intervening bluffs on both sides of the Mississippi, all the way to the Falls of St. Anthony, where the waters of that stream shoot down an inclined plane of the fossiliferous limestone, and then precipitate themselves over ledges of the same rock, which overhang the underlying, crumbling, soft, white sandstone; making, in all, a perpendicular cascade of sixteen feet.

Three miles above the Falls, the protozoic rocks are lost to view under superincumbent beds of drift; but they can be traced up the valley of the Minesota, as high as the confluence of the Waraju River.

For a distance of nearly seventy miles, in a direct line, and more than eighty miles by the course of the river, no underlying rocks are seen unequivocally in place; but, at some of the intervening rapids, huge masses of granitic rocks rest on the bed of the river, which, though they appear like large erratics, are probably either in place, or not far removed from the parent rock.

At Osakis Rapids, and in the vicinity of Little Rock, chains of crystalline rocks cross the Mississippi, in low ranges, with a north-easterly bearing, succeeded by crystalline schists, exposed, at intervals, for a few miles, on Knife Rapids.

These limited exposures of igneous rocks, and metamorphic slates, together with a ridge of quartzite, forming Esconaby hights, (which Dr. Norwood found,) crossing the Mississippi at the Falls of Pokegoma, about two hundred and fifty miles still higher up, are the only exposures of solid rocks which occur on this river, from the Falls of St. Anthony to its extreme sources.

Similar partial protrusions of crystalline and trappean rocks show themselves, occasionally, at distant intervals, crossing the eastern tributaries of the Mississippi, north and east of the boundaries assigned to the lowest sedimentary strata west of the Mississippi; but the whole interior of Wisconsin and Minesota, from the eastern confines of these strata to the sources of the Mississippi, and the heads of its eastern

branches, may be described as a vast region overspread with drift, of fine and coarse materials, which reach even to the summit-levels, and conceal from view, except over very limited areas, the platform of igneous and metamorphic rocks, on which it reposes.

A continuation of analogous transported materials,—in which, however, trappean bowlders are, probably, more abundant,—can be traced in the descent toward the basin of Lake Superior, where they appear in a succession of terraces, overlying, and partially hiding, both stratified and metamorphic strata, as well as crystalline and intrusive rocks, belonging to different geological epochs.

Here the underlying formations are more frequently to be seen; still they show themselves only in narrow ranges, which, for the most part, appear at intervals, being continuous only for about twenty or thirty miles, as they pursue a south-westerly curve, between the Montreal river and the Maringonin Fork of Bad river: while beyond this, toward the Brulé and Fond du Lac, these formations penetrate the drift only at a few isolated and distant localities. They usually succeed each other in the following order, from the summit-levels, toward Lake Superior:—Granite and quartzoze rocks; metamorphic slates; black, red, and green-stone traps.

Extensive plains of red clay stretch between the igneous ranges and the lake, at a lower level than the coarser drift, and rest, unconformably, upon the red sandstones and shales, which they conceal, except at the prominent rocky shores; so that, for many miles, even the coast sections, in the bays and receding shores, are mostly composed of those red clays and marls.

In Wisconsin, a very limited area, indeed, of this region of drift, intersected by igneous ranges, and outcrops of red sandstone and conglomerate, can be regarded as a mineral district. The present actual discoveries of ore may be said to be confined to a narrow, wedge-shaped belt of country, running, in a south-westerly curve, from Montreal river, toward the Middle Fork of Bad river, hardly exceeding, at its broadest part, ten or twelve miles, and to a few isolated protrusions of trap, seen, at distant points, as far as the west end of the Lakes; and that portion affording copper ores, which may be said to cover only the ranges of black and red trap, will average less than the fifth part of this width; since the belt of metamorphic slates, bearing the magnetic iron, is more extensive than the copper country north of it.

Even over this circumscribed district, the superficial indications of

copper ores in Wisconsin, between the Montreal and Brulé rivers, are, on the whole, unfavorable to profitable mining, for reasons given in the special report, of the "South Shore," and which will be found more fully explained and discussed in Col. Whittlesey's report.

Every location made by explorers and mining companies in the Chippewa Land District, on the waters of the Montreal, Bad, and Brulé, has been finally abandoned; the metal not having been found in regular veins, but only sparingly scattered through trap and amygdaloid: the former being, usually compact, hard, and expensive to work, and never extends any great distance into the adjacent conglomerate and amygdaloid.

Toward the west end of the lake, where the trap ranges cross the Poplar, the Aminecan, and Black river, a small tributary of Left-Hand river, the prospects for profitable mining are somewhat more favorable, still, even there, all mining operations have been, for the present; discontinued.

On the North shore of Lake Superior, in Minnesota, between Fond du Lac and the British possessions, we have a repetition, in an inverse order, of the same formations that exist on the south shore, in Wisconsin, but far more complicated in their details, since the eruptions of trap and other intrusive rocks, have been much more frequent and energetic, the disturbance consequently greater, and the metamorphism of the sedimentary strata proportionately increased: so that in some instances it will defy the skill of the most experienced geologist, to decide whether certain rocks were originally sedimentary or igneous; and this decision becomes more puzzling, since there are frequent instances both of overlying and tabular trap, and even alternations of the same rock conformable to the stratification of deposits of aqueous origin. The descriptive details of this interesting region will be fully given in Dr. Norwood's report, whose special duty it was to survey this portion of Minesota.

As already observed, there is on the north shore of the lake a repetition of the formations, in an inverse order to that which is found on the south shore. This, however, is only in a geographical sense; for relatively to the lake they are in the same order, because the red sandstones which make the coast sections of the south shore, produce a synclinal axis in the bed of the lake, and reappear on the north shore, where they constitute, as before, the coast sections; while the slates, conglomerates, and associate traps, are crossed in succession as you proceed into the interior, followed by the metamorphic slates and gra-

nitic rocks; which latter formations prevail again toward the summit levels, form the ranges of hills and numerous islands, traversing, intersecting, dotting, and inclosing the innumerable lakes and swamps that abound throughout the so-called "region of rocks and water," that skirts the northern confines of the United States as far as Lake of the Woods.

The evidence of the ocurrence of regular mineral veins on the north shore is more frequent, and the symptoms of their metalliferous character are more favorable than on the Wisconsin shore; the area occupied by the trap is of considerably greater extent.

The geologist is here, however, not aided in his inferences by the discoveries and observations of the pioneer miner; for the country is, as yet, inhabited by the Indian, and its geology and mineralogy were unknown until the partial explorations made during the second year of this survey, in the summer of 1848, and the more detailed one of 1849. Conclusions have, therefore, to be drawn from superficial indications, and geological and mineralogical analogies, aided only by the few facts obtained at a single location, situated beyond the possessions of the United States, where some mining operations have been commenced at Prince's bay and the adjacent island. All of which prove at least the existence of occasional mineral veins, bearing copper, associated with small quantities of gold, silver, cobalt, zinc, lead and iron.

It is not at all improbable that metallic veins, even of the precious metals, may hereafter be discovered in connection with the numerous quartz veins, which have been observed to be widely distributed through the crystalline and metamorphic formations that have an extensive range along the northern confines of the United States, especially since discoveries of gold are being made in Canada, in similar geological positions.

The time allotted for this survey did not admit of any thing more than a mere reconnoissance of that district, no detailed examinations having been made of this northern country, excepting along the water shed bordering the lake.

Drift deposits, similar in character to those in Wisconsin, south of Lake Superior, occur also in Minnesota, north of the Lake; but the underlying rocks are not so generally concealed by them, partly on account of their greater elevation. This, however, is only true of the most northerly regions; for around the sources of the Mississippi and Red River of the North, the surface covered by the finer siliceous and argillaceous drift is very extensive—indeed, almost universal.

Further north-west, along the valley of Red River of the North, the drift rests on the magnesian limestones of the Silurian epoch, judging from the few out-crops which have been discovered during the survey. These occur at the great bend of Red river, in latitude 46° 13′; at Fort Garry, in latitude 50° 7′ 37″, and on the east shore of Great Lake Winnepeg, in latitude 50° 32′. A range of the same kind of limestone was observed crossing Rainy river, in latitude 48° 45′ 54″, and loose fragments were also found in the debris of the shores of Otter Tail Lake, and at other localities near the sources of Red river.

Over this region of country, and to a great extent around the sources of the Mississippi, the coarse bowlder drift is less abundant than it is further north and north-east, near the boundary line of the United States, and on the summit levels inclosing the basin of Lake Superior, while the finer drift materials, such as sand, gravel, ash and buff-colored clays, and marly earths, predominate.

"The terrace of high land, bordering the plains of Red river on the west, and known as Pembina mountain, in latitude 48° 55′, is composed of incoherent sand, gravel, and shingle, forming a table-land, elevated about 150 feet above the general surface of the plains. This terrace is probably only the northern prolongation of the Plateau du Coteau des Prairies.

Along the western confines of the Dubuque district, in Iowa, to wit: along the valley of Red Cedar river, the upper magnesian limestone is succeeded by a calcareous formation of a more recent geological epoch, which corresponds to the Devonian system of Europe. This latter group of rocks has been traced along this river, nearly from its source to within a short distance of its confluence with the Iowa river, viz: from latitude 41° 20′ to 43° 10′. No where, within this distance, do any of its beds present the appearance of being being metalliferous.

The formation in question has been found to extend west to the Iowa river, being exposed on that river for a distance of twelve miles above Iowa City. In the northern part of Johnson county, on section 28, township 81, north, range 7 west of the fifth principal meridian, is the last exposure of limestone referable to this system, in ascending the Iowa river. From Iowa City this formation extends a little south of east toward the Mississippi, in a zone about thirty miles in width, where Dr. Shumard traced its limits from a little below Parkhurst to near Wyoming.

On section 29, township 81, north, range 8 west of the fifth principal meridian, not far from the line between Johnson and Iowa counties, an

uplift of Carboniferous sandstone is encountered. This is probably near the eastern limit of the Des Moines coal field, though the Carboniferous limestone extends a little further: to the dividing ridge between the Iowa and Red Cedar rivers. From this point, the boundary line bears off north-west by the corner of Iowa county, and south through Johnson county. Carboniferous rocks appear at intervals on the Iowa river, as high as latitude 42° 30′, where they are finally lost to view under an extensive superficial drift.

The Iowa river meanders near the eastern margin of this coal field, so that it is only at a few points high up on this stream, in and near the Big Woods between latitude 42° and 42° 30′, that any seams of coal present themselves to view near the river; and these are of inferior quality. But it is not improbable that coal might be discovered in the western part of Johnson and Iowa counties.

Just below the entrance to the Big Woods, there are ledges of magnesian limestone exposed, which have much the lithological aspect of the lead-bearing rocks of the Dubuque district of Iowa; these appear, however, to belong to a different system, and to be intercalated beds of Carboniferous limestone. From this fact, as well as from the general appearance of the country, and its levelness, the absence of important axes of disturbance, and from the rocks in question being of little thickness, it is hardly likely that they will prove to be productive in lead ore.

From the Iowa river, as has been already said, the Carboniferous rocks have a southerly bearing, sweeping off toward the Mississippi, through Johnson, Washington, Louisa, Henry, Des Moines, and Lee counties, so that on the Des Moines river, the south-eastern margin of the upper series of Carboniferous limestone crosses that stream, not far from the Missouri line, and distant from the Mississippi, in a direct course, only about ten miles.* From this point along the course of Des Moines river, up to latitude 42° 33′, i. e.—five or six miles beyond its Lizard Fork, the Carboniferous rocks extend without interruption, so that in the direction of the valley of the Des Moines, it is upwards of two hundred miles across this great coal field. Westwardly, it extends from Des Moines river nearly across the State of Iowa, and includes a considerable portion of Missouri. The entire area of this coal field in Iowa alone, can not be less than twenty thousand square miles, and the portion situated in the State of Missouri, about fifteen

* There are a few outliers a little east and south of this line.

thousand square miles—in all, embracing a country nearly equal in extent to the State of Indiana.

The boundary line of this coal field, after crossing the Des Moines, bears nearly south into the State of Missouri, through Clark, Lewis, and Marion counties, to near the junction of three forks of Salt river; thence through the western part of Ralls county, on toward the head waters of the Riviere au Cuivre, in the eastern part of Audrain county, and north-west corner of Montgomery county, when it bears in a south-easterly curve through Calloway toward the Missouri river, which it crosses near its confluence with the Osage; leaving a belt of country of about ninety miles in width, between the coal region and the out-crops at Charbonniere, and the coal pits worked on the Riviere des Pères, in St. Louis county; which, in fact, are outliers of the Illinois coal field. From the Missouri river, the boundary of this same coal field bears with a westerly curve up the valley of the Osage, on the north side, and crossing that stream only for a very limited distance at three points, to wit: in Camden county, near the mouth of Nianqua; in St. Clair county, near the mouth of Sac river; in Bates county, near the confluence of the Little Osage. Thence the line bears with a north-easterly curve, toward the western confines of Fayette, recrossing the Missouri at Wellington; thence up the valley of the Missouri, toward the narrows of the Nishnebotna, keeping from ten to twenty-five miles east of the Missouri, where the coal measures, however, only occupy the more elevated ground; thence in a course a little east of north, up the valley of the Nishnebotna toward the head waters of the Three Rivers; thence in nearly the same course toward the Lizard Fork of the Des Moines.

Though of so great an area, this western coal field is comparatively shallow in Iowa*, probably hardly exceeding fifty fathoms in thickness.

It consists of three well-marked divisions—a lower calcareous, a middle argillaceous, and an upper silicious. The lower division on the Des Moines, may be about one hundred feet; the middle from fifty to seventy-five or one hundred feet, and the upper from eighty to one hundred or one hundred and twenty-five feet. The beds of coal at present discovered are confined to the middle division, so that the extent of the measures affording coal in Iowa, is probably confined to

* It is probably thicker in Missouri.

a vertical thickness of less than one hundred feet. The thickest coal bank that has yet come under my observation in Iowa, is from four to five feet. Much thicker beds are, however, known in Missouri, near the south-west margin of the same coal field.

Along the whole line of the valley of the Des Moines, the beds of Carboniferous rocks appear to have been subjected to repeated slight dislocations, or faults, by which the strata have been alternately elevated and depressed, so that the inferior Calcareous, and even the middle division, after being carried by the dip quite out of view underneath the water courses, are again and again thrust up, forming a series of step-like protrusions, often abrupt, yet without tilting the strata much from the horizontal position of their bedding.

With regard to the quality of the Iowa coal, it is difficult to form a correct opinion, because so few of the coal banks have been worked into, or even stripped of disintegrated rubbish, and because, at many localities, the beds, by reason of slides down the face of the shaly banks, often conceal a part, or even the whole of the out-crop ; so far, however, as I can judge from the collections that I have been able to make, I consider the quality rather below the average of the coals of the valley of the Ohio.

Too frequently, the seams are impregnated with pyritiferous shaly matter, which effloresces on the exposed surface in the form of sulphate of iron or copperas. Still, the descriptive details to be embodied elsewhere in the present report, will indicate a few fair samples of coal, and doubtless future search will develop others, while many of the seams which at their out-crop are unpromising, may, on being worked into, improve in quality.

If sufficient time be allowed for a chemical investigation into their qualities, it is proposed, for the benefit of the settlers in Iowa, to subject to a rigid chemical analysis, specimens selected from those beds which have a sufficient thickness to justify experimental mining operations, with a view to test their commercial value.

The middle division of this coal field affords also, at many localities, iron stones of various qualities, associated frequently with hydraulic calcareous cement, which occurs either in the form of disconnected septaria or regular beds. In the same geological position, at many localities, crystalized selenite has been observed, which accumulates in quantity high up on the Des Moines ; and finally, a few miles below its Lizard Fork, that mineral expands itself into heavy beds of gyp-

sum, which show themselves on both sides of the river for the distance of about three miles, exposed in horizontal beds, with a thickness of from twenty to thirty feet.

The iron-stone occurs, sometimes, in the form of concretionary nodules, sometimes in continuous bands of several inches in thickness, interstratified in the shales. In the chapter of the report embracing the detailed descriptions of the Carboniferous rocks of Iowa, will be found the analysis of some of these iron ores, together with other more precise information regarding them.

On Soap creek and its branches, in Davis county, where the middle division of the coal series prevails, there are several salt springs, which were tested qualitatively on the spot, and found to contain a portion of chloride of sodium. The amount of the precipitated chloride of silver, as well as the taste of the water, indicated, however, only a weak brine. By boring, a stronger water might possibly be obtained. Nevertheless, the shallowness of these coal measures, the frequent rupture of the strata, and consequent local reversion of the dip; together with the fact of the lowest division being composed chiefly of limestone, in place of sandstone, are unfavorable indications of the existence of a plentiful supply of deep-seated brine, or of nests of salt, whence the permeating waters might become saturated, and carry the saline matter to the surface.

All along the eastern margin of the Illinois and Indiana coal-field, as well as the western margin of that portion of the same basin which stretches through Ohio, Kentucky, and Tennessee, where productive salt works have been established, the base of the coal formation, down to the archimedes, pentremital and oölitic limestones is arenaceous; and the borings for salt water, at these localities, have uniformly been carried through porous and cellular standstones, with vegetable impressions. The lower members of the Iowa coal-field, as has been already stated, consist chiefly of calcareous rocks, especially around the southern and western margin of this basin, on the Des Moines and Missouri rivers. In this respect, the Iowa coal measures differ, essentially, from those of Ohio, Virginia, Kentucky, and Indiana. This fact serves to clear up a difficulty which has, hitherto, existed, with regard to the true geological position of certain limestones in the vicinity of St. Louis, which can now be shown to form that portion of the carboniferous limestone, which is known in Yorkshire as the Upper or Yordale series of the carboniferous limestone of England.

The Mississippi river, from the mouth of the Iowa to that of the

Des Moines, flows over beds of sub-carboniferous limestone, which here forms a belt, about thirty miles wide, in the depressed portion of the Mississippi Valley, in which no seams of coal have yet been detected.*

The bend of the Mississippi, north of this, cuts into the north-western margin of the Illinois coal-field, as it sweeps around by Muscatine, from the mouth of Rock river to near the Iowa. Here the zone of sub-carboniferous limestone is almost, if not entirely lost, and the coal-measures abut directly on the Red Cedar, and magnesian limestones, of the age of the Devonian and Upper Silurian periods. South of the Des Moines, the sub-carboniferous limestone extends on the Mississippi, as far as Quincy and Hannibal.

Twelve or thirteen miles west of the Mississippi, in Pike county, on a small stream known as Zeno creek, a low, narrow range of limestones, with a south-west bearing, suddenly appears, possessing the same characters as the rocks on Turkey river, in Iowa, which can be shown, by the organic remains, to be contemporaneous with the Trenton limestone of New York.

It is not yet positively known whether these protozoic rocks, in their northerly extension, cross the Mississippi into Illinois, but they bear south toward the Missouri, which they cross in Franklin and Gasconade counties.

At a point on that river, in Franklin county, which was called, by Lewis and Clark, "Tavern Rock," there are high bluffs, some of which are highly magnesian, resting on sandstone. Here, at a hight of two hundred and forty feet above the river, Dr. Shumard and myself found light gray, buff, and bluish beds of limestone, similar, in lithological character, to the fossiliferous beds at the Falls of St. Anthony, and containing many of the same fossils, seven or eight species of which are identical with those found in hills and ravines surrounding Cincinnati.

It is not improbable that this formation is accompanied by a narrow zone of pure limestones, like those near the head of the Falls of Ohio, at Louisville, since we detected, on the opposite side of the Missouri, in Calloway county, rocks of this character, containing several of the characteristic fossils of that geological period.

If the formation of Zeno creek, Tavern Rock, and Gasconade county,

* An eighteen inch seam of coal occurs a few miles south-west of Keokuk; but it occurs high in the bluffs, above these limestones, and is merely an outlier of the Des Moines coal-field.

crosses the Mississippi above Savannah, then there is a short interruption of the carboniferous limestone on that stream, near the mouth of Salt river, in Pike or Ralls county, which, otherwise, occupies the whole immediate valley of the Mississippi, from beyond the mouth of the Iowa to near the mouth of the Ohio.

At the abrupt bend of the Mississippi, where it unites with the Missouri, that river has worn its channel through the western outliers of the Illinois coal-field into the upper series of carboniferous limestone, which just underlies the lowest workable seam of that coal-field, and which corresponds, in age, to the northern type of upper limestone, described in Phillips' Geology, (of Yorkshire,) as the Yordale Series of Carboniferous Limestone.

An inspection of the map of Iowa will show a peculiar feature in its physical geography. The two rivers, Wapsipinicon and Red Cedar, flow, for a great part of their course, nearly parallel to each other, in a south-easterly direction, and not very far apart. As they approach the Mississippi, however, they suddenly diverge; the Red Cedar running to the west of south, and the Wapsipinicon to the east. This deflection takes place around the north-western margin of the great Illinois coal-field, where there is an abrupt change—both in the geological formation, soil, vegetation, and even climate,—and where, as will appear hereafter, there are sudden depressions and elevations of the strata.

That portion of the State of Iowa which lies north of latitude 42° 30′ and west of longitude 92°, or 92° 30′ is entirely composed of drift of sand, gravel, and bowlders, of moderate size. Here the face of the country presents a multitude of low, detached knolls, surrounded by wet morasses. The drift deposits extend even to the summits of these knolls. The Sioux country, north of the State line, and west of the same longitude, embracing the lands lying on the heads of the Iowa and eastern branch of the Des Moines, appear to be similarly constituted. Near Minesota river, outcrops of lower protozoic strata are occasionally visible in the cuts of the streams; but, even here, the soil of the higher ground rests on drift deposits, extending nearly down to the water-courses. Higher up, on Minesota river, near the confluence of Waraju creek, crystalline rocks succeed the protozoic strata; but here, too, the drift prevails, so that the granitic rocks are only accessible to, or in the immediate bed of, the river.

Such are the general boundaries, and leading features, of the great geological formations of the north-west.

8. On the Cause of Saltpetre Explosions. By George C. Schaeffer, Professor of Chemistry and Natural Philosophy, Centre College, Danville, Ky.

The disastrous effects of the great fire of July, 1845, at New York, called the attention of chemists to the question of the explosibility of nitre—a question often before discussed, but never with such serious consequences dependent upon the issue. The reputation and the fortune of the members of a firm of high standing, were at stake.

The opinion generally held was, that large quantities of gunpowder had been illegally stored in the building. The assertion of the members of the firm, and all parties engaged in their establishment, was, that nothing but saltpetre (to the amount of over three hundred thousand pounds), together with ordinary combustible merchandise, was contained in the building.

Hence arose two questions: first—was gunpowder present? second—could nitre produce such effects? The first of these was answered in the negative, and that most unequivocally, by all the evidence. The second question, as a matter of course, was referred to chemists.

The explosibility of nitre was maintained on the ground of previous occurrences of similar character, and upon various supposed reactions, and their physical consequences. It is not intended to enter into a discussion of these proposed solutions of the question; but it may be remarked that, in almost every instance, the same sort of reasoning would apply to hundreds of articles of merchandise, which might, on such principles, be considered explosive.

Actual trial to produce these explosions on the large scale, was in no case attended with success.

The result was the acquittal of the parties on the charge of storing gunpowder, although the chemical evidence offered was at best rather vague and contradictory.

No chemical examination of the copious saline efflorescence found in the cellar of the building after the fire, has ever been published. This substance should have yielded sulphurets or sulphates, in cases of large quantities of powder. The writer of this notice examined this deposit, without obtaining the slightest trace of these salts.

Several years before the fire of 1845, the writer had made a series of experiments upon the deflagration of nitre in the combustible, and these proved what was gathered from various authors—that an impor-

tant reaction took place, which has, however, never yet been hinted at in the various published theories of these explosions.

The discussion of the question at an earlier date, would have been impossible, as any tendency to undo the reasoning upon which the explosibility of nitre had been settled, would have been resented as a personal attack upon parties recently interested so deeply.

A sufficient time has now elapsed to obviate all such unpleasant consequences—and a recent publication of Dr. Hare has again called attention to the subject. The scientific interest of the question is not diminished, while its commercial relations are worthy of serious consideration. It is now illegal, in some places, to store saltpetre in quantities exceeding three hundred pounds, while in others it may be stored, and even burned, as recently in Philadelphia, without violating law, or doing damage.

The reaction, above mentioned as never having been taken into consideration is the following: Whenever potash, or its carbonate, is heated with carbonaceous matter and gaseous nitrogen, cyanide of potassium is formed. In this way Fownes obtained that salt, using perfectly pure materials, while its formation at the tongues of high furnaces may be explained in the same way. L. Thompson has likewise proposed a mixture of dense carbon, carbonate of potash, and iron filings, which, heated in contact with the air, absorb its nitrogen and form cyanide—the quantity of which may readily be estimated by the amount of Prussian blue furnished.

Thompson also says that a mixture of coke or coal, nitre and iron filings, will furnish, on deflagration, an abundance of Prussian blue.

Berthier also mentions that the deflagration of nitre and tartar, particularly when in a crucible, will always furnish some cyanide.

Thompson notes the increased proportion formed, as the quantity of materials employed is increased, and likewise the influence of iron filings in favoring reaction at a lower temperature.

From all these authorities, and from the evidence of numerous experiments, we can not avoid the conclusion that no theory of nitre explosions is complete, which does not take notice of the formation of cyanide of potassium.

But in as far as this compound is formed, it retains all the nitrogen of the saltpetre, and even as carbon is taken into composition, it is very evident that this reaction is diametrically opposed to that commonly assigned, viz: the sudden evolution of all the nitrogen, and of enormous quantities of carbonic acid. Indeed, so strikingly different

would be the results, that the writer for a long time doubted the possibility of producing an explosion of nitre, until he accidentally met with a notice of the fact that cyanide of potassium would detonate when heated with nitre. Here, then, is a solution of the whole difficulty. Cyanide of potassium is *always* formed during the deflagration of a large quantity of materials, and in great quantity when finely divided iron is present; a portion of melted but undecomposed nitre, coming in contact with salt, would produce an explosion of terrific energy.

The results of the experiments made upon the subject, are the following: By the addition of iron filings to the deflagrating mixture, we may always insure the formation of cyanide, even when but a few grains (less than one hundred) are used. The nature of the organic matter employed, has considerable influence on the result; but the variations are too numerous to be detailed, and are reserved for future study.

The cyanide of potassium, even in very small quantity, when laid on melted nitre, may be made to detonate, either by raising the temperature, or by the presence of the smallest portion of an incandescent body. The sharpness of this detonation is very remarkable, and if we can imagine the effects increased in the ratio of a few grains to a few hundred pounds, it would seem sufficient to account for all the disastrous effects of the fire of 1845. Yet instead of hundreds, it is not improbable that thousands of pounds of cyanide were formed.

There is only one difficulty remaining—what were the circumstances at this fire, which favored so remarkably the formation of cyanide of potassium? The presence of finely divided iron would answer this question, but having no account of the articles present in the building, there remained a doubt, until it was recollected that the kegs supposed to have contained powder, were in reality kegs of nails.

This, then, furnishes the best material, in its best form, to favor the formation of cyanide. The melted nitre falling with burning matter, the red hot nails flowed into the cellar, and at least in portions must have been converted into cyanide of potassium. The melted nitre from above, or from the sides, coming in contact with this, would be able to produce an explosion of most fearful energy.

If this reasoning prove correct, we have the remarkable result, that iron, hitherto not even suspected of having any connection with the explosions, is a most dangerous addition to the deflagrating materials in a fire.

9. Chemical Action of Feeble Currents of Electricity. By Daniel Vaughan.

It is stated by Liebig, Thompson, and other chemists, that water, exposed to the solar light, emits oxygen, even after it has been deprived of every trace of microscopic vegetation. The production of this oxygen, which seems to be evolved almost as abundantly in these cases as it is when plants are present, they ascribe to the minute animals which the water contains. I repeated the experiments by which they were led to this conclusion, exposing several inverted glass jars filled with water, to the solar rays; and I observed that gas was slowly evolved from all, and collected in the upper part of the jar. But on mixing arsenic and other poisonous substances with the water, no effect was produced in the rate at which the evolution took place, though it must have destroyed the animals to which the phenomena have been ascribed. From this it appears that the presence of the oxygen does not depend on animal life, and it evidently results from the decomposition of the carbonic acid which the water always absorbs from the air.

This conclusion I confirmed, by exposing to the open air two plates of clear water, impregnating one with carbonic acid by means of sugar in a state of fermentation. A vial of fermenting sugar, in solution, was placed in one of the plates, and covered with a vessel of intermediate size, which caused the carbonic acid to impregnate the water. After a few days, this plate contained a much more copious deposit than the other, though both had equal opportunities of receiving dust from the air. The excessive deposit must therefore arise from the decomposition of the carbonic acid. Numerous facts prove that in the same manner, the amount of this gas which water and moist surfaces continually absorb from the air, is decomposed, and serves to supply the principal part of the humus of the soil.

This decomposition is caused by the action of light, together with the electrical disturbance arising from the formation of vapor. It appears that carbonic acid, when dissolved in water, yields to the most feeble current of electricity. When water evaporates, the negative state of the surface, and the positive state of the vapor, causes the decomposition of this acid, the oxygen being carried away by the vapor, and the carbon retained by the surface which performs the office of the negative electrode. The carbon combines with the elements of the water, in

accordance with the well known tendency which elements have to unite with the electrode at which they are separated. The great obstacle to the chemical action of feeble electric currents, proceeds from the play of affinity in the elements, resulting from decomposition; but from the indifference of carbon for oxygen at a low temperature, this causes no impediment in the present instance. It is for a similar reason that the chemical action of plants is exerted almost exclusively on compounds of carbon.

FOURTH DAY: THURSDAY, MAY 8, 1851.

(Afternoon Session.)

The Association met at 8 P. M.—the PRESIDENT in the Chair.

The following papers were presented:

1. ON THE DIFFERENT SYSTEMS OF ELEVATION WHICH HAVE GIVEN CONFIGURATION TO NORTH AMERICA, WITH AN ATTEMPT TO IDENTIFY THEM WITH THOSE OF EUROPE. By J. W. FOSTER and J. D WHITNEY, U. S. Geologists for the Land District of Lake Superior.

THERE are three grand systems of elevation which appear mainly to have determined the outlines of North America.

1. The first we denominate the *Lake Superior System*, since it is developed on both shores of that Lake, forming the "*divortia aquarum*" between Hudson's Bay and the valley of the St. Lawrence, and between the river systems of Lake Superior and Lake Michigan. It extends almost uninterruptedly from the coast of Labrador to the sources of the Mississippi, and probably beyond. Its direction is a few degrees north of east, and south of west, and its age may be dated as anterior to the dawn of the Silurian Epoch, since the Potsdam sandstone is found reposing in a horizontal position upon the upturned edges of the Azoic slates, or occupying the pre-existing depressions in the granite. These granites and schists formed the ancient continent, whose culminating points in the Lake Superior district, rose not more than

a thousand feet above the waters of the Silurian ocean, as evidenced by the sandstone which reposes at its base.

It is stretched out in a long and narrow belt of land, with here and there a detached island, like that of the iron region of Missouri, or that of Carp river. Thus it will appear that the direction of the ancient land was east and west, and not north and south, as is generally supposed.

2. The second may be designated as the *Appalachian System*, which has given configuration to the eastern slope of North America. Its elevation took place at the close of the Carboniferous epoch. It commences near the outlet of the St. Lawrence, and terminates in northern Alabama, pursuing a course nearly north-east and south-west. The series of rocks composing it, according to the Messrs. Rogers, present an unbroken succession of conforming strata, from the lowest members which repose immediately on the primary or metamorphic rocks, to the highest Carboniferous strata. The new Red Sandstone, which extends continuously in a narrow belt from the valley of the Connecticut to beyond Virginia, reposes immediately upon the folded strata of this chain, and furnishes not the slightest indication of having been disturbed by the movements which produced the axes beneath.*

3. The third may be denominated the *Rocky Mountain System*—a prolongation of the Andes—which ranges in a direction a little west of north, and east of south, from California to the Arctic ocean. "This great mountain," remarks Mr. Dana, "the back-bone of America, is not a narrow line of summits, but spreads out over a base of more than fourteen hundred miles, one foot literally bathed by the waters of the Mississippi, and the other dipping beneath the Pacific. This fact is well shown, in a sectional view, by Fremont, one of the interesting results of his explorations. They are properly a gentle swelling of the surface, whose average inclination is seven and eight feet to the mile ; and on the declivities, as well as on the top, are numerous lofty ridges.†

There is little doubt that the period of its elevation was subsequent to the deposition of the Cretaceous System, and therefore among the comparatively recent geological events. On both sides of the equator it is, in places, flanked by Calcareous strata, containing, according to L. v. Buch, fossils characteristic of the chalk. These were also ob-

* Trans. Am. Geologists, (1840 and 1842), p. 522.

† Geology of the Exploring Expedition, p. 612.

served by Humboldt, between Guambos and Montan, nearly thirteen thousand feet above the level of the sea. Neocomian fossils were observed by Tschudi in the Cordilleras of Peru, and the explorations of Fremont and others in the Rocky Mountains, confirm these views.

There are other but subordinate systems of upheaval, all of which, in the present state of geological science, it is impossible to trace out.

We will advert to two of these, which are well defined in the Lake Superior district:

4. *The System of Kaministiquia,* which occurs on the north-west coast of Lake Superior, between Pigeon river and the head of Thunder bay. It is the most ancient, so far as we know, of all the systems of North America, and thus far has been traced only over a limited area. Its elevation took place before the close of the Azoic period, since the upper members of this series are found abutting undisturbed against the granite axis. Its direction is nearly north-east and south-west.

5. *The System of Isle Royale and Keweena Point.* This embraces the crystalline greenstones of the Copper region, which lifted up the bedded trap, conglomerate, and sandstone, at angles varying from 40° to 70°. The precise period of its elevation can not be determined, but it probably took place about the close of the Lower Silurian epoch, since we find the Hudson river group of the Sturgeon river valley disturbed by it. The direction of these axes is somewhat variable. On Isle Royale, they are N. 65° E., but on the southern shore they bear N. 52° E.,* though subject to minor deviations, the trap ranges in many places assuming crescent-shaped forms.

We next propose to inquire how far the mountain chains of North America can be identified with those of Europe; and, in the prosecution of this task, it will become necessary to institute a comparison between the various fossiliferous groups which have been disturbed on both continents, by these several systems of elevation, and to determine their respective ages. The period, perhaps, has not arrived for the correct determination of this parallelism, in the minor groups; but with regard to the great natural divisions, there can be little doubt.

In order fully to understand this subject, a few preliminary remarks are deemed necessary.

* This is the direction of a line drawn from the southern limits of the trap on the Montreal river, to its southern limits on Keweena Point

De Beaumont's Theory of the Elevation of Mountain Chains.

The Determination of the relative age of mountain chains by observing the inclined and horizontal strata, which rest against them, was first suggested by L. v. Buch; but to Elie de Beaumont belongs the credit of having wrought out the details of this theory, and first applied it to the several mountain chains of Europe.

Starting with the self-evident proposition that those strata which have undergone upheaval, must be more ancient than the cause of that upheaval; and another proposition, equally evident, that all strata found abutting against the flanks of a mountain, are more recent than the mountain, he inferred that all mountain chains are not contemporaneous, but have been raised at different epochs; and, consequently, that the epoch of elevation must have had a great influence on the distribution of sedimentary strata. It is assumed that at each revolution which our globe has undergone, the forces of upheaval acted in parallel lines, and that therefore the age of a mountain chain may be inferred with great probability from its direction; and that the lines of fracture and elevation are not mere local phenomena, but possess a great degree of uniformity, and traverse entire continents.

In order that we may determine the correctness of this celebrated theory and its applicability to our own country, it becomes necessary to ascertain how far a parallelism may be traced in the contemporaneous lines of upheaval in the two hemispheres. For this purpose, we give an abstract of De Beaumont's views with regard to the different epochs of elevation, accompanied by such comments as our own observations have suggested.

In his first publication,* in 1829, he recognized only four systems of mountain chains; but the year following, he augmented the number to nine:†

1. System of the main chain of the Alps—direction east and west; which raised the old Diluvial deposits.

2. System of the Western Alps (from Marseilles to Zurich)—direction N. 26° E., which raised the Upper Tertiary.

3. System of Corsica and Sardinia—direction north and south; which raised the Lower Tertiary.

* Recherches sur quelques unes des Revolutions de la Surface du Globe. Compte Rendus de l' Acad. des Sciences.

† Annales des Sciences Naturalles. Tomes 18, 19.

4. System of the Pyrennees and Appenines—direction north-west and south east; which raised the Chalk and Greensand.

5. System of the Cote d' Or, (Burgundy), the Erzgebirge (Germany)—direction south-west and north-east; which raised the Jura limestone.

6. System of Vendée, Thuringia and Bohemia—direction north-west and south-east (therefore parallel with the fourth system); which raised the Trias.

7. System of the Rhine—direction north and south or north north-east and south south-west; which raised the sandstone of the Vosges, (which he considers distinct from the Variegated), and the Zechstein.

8. System of the Netherlands and South Wales—direction north-east and south-west; which raised the Coal measures.

9. System of Ballons (Vosgos) and Bocage (Western France)—direction N. 74° W., S. 74° E.; which raised the carboniferous limestone.

As early as 1831, Mr. Sedgwick remarked that the mountains of Westmoreland, the Grampians, and the Lead Hills, had been elevated prior to the deposition of the Old Red Sandstone, and consequently prior to any of the above named systems. Accordingly, in 1833, another system was created, under the name of "Westmoreland and Hundsrück"—since there was a general parallelism observed in the direction of the two mountain chains, varying from north $67\frac{1}{2}°$ east to north $37\frac{1}{2}°$ east.

In his last work, De Beaumont has shown that there are at least three systems included in the above named direction; and since M. Riviere had noticed another very ancient system on the south-western coast of Vendée, running north-west and south-east; three more systems were added, all of which are older than the oldest mentioned in the above list. They are as follow:

1. *That of Westmoreland and Hundsruck*—direction at the Bingerloch, on the Rhine, north $58\frac{1}{2}°$ east; which raised the Palæozoic rocks, below the Old Red Sandstone.

2. *That of Morbihan*—Direction at Vannes, (Brittany), N. $51\frac{3}{4}°$ W.; which took place after the deposition of the Bola limestone, of Wales.

3. *That of Longmynd*—direction at Bingerloch, N. 31° 15′ E.; which took place after the deposition of the Green slates of Wales, and the field-stones.

4. *That of Finisterre*—direction at Brest, north 68° 15′ east; which took place after the deposition of the oldest schists of Brittany.

5. *System of the Vendée ;* direction at Vannes,—latitude 47° 39′ 26″ N., longitude 2° 47′ W.—N. 22° 30′ W. Age ; anterior to the system of Finisterre, and is supposed to have been elevated after the deposition of the Green slates of Belle Isle.*

However ingenious this theory, in its application to the general direction of mountain chains, it would be hardly safe to infer the age of the associated sedimentary rocks, from their line of bearing at a particular point. In examining the structure of mountain chains, it will be found that they seldom pursue an undeviating course. Sometimes they are curved ; sometimes straight in their constituent lines, but curved in their individual lines ; sometimes individual lines are straight, while the general direction is curved ; and sometimes the longitudinal lines are intersected by traverse ones.† "The more thorough," remarks Mr. Dana, "the examination of the trends of groups of islands, (which are the culminating points of sub-marine ridges), and of mountain chains, the more distinctly will this system of things be apparent ; and instead of straight lines of parts of great circles, it will be found that the predominant courses of the earth's features are curves." In illustration of this remark, we need only to refer to the trappean ranges, not only on the borders of Lake Superior, but elsewhere, which exhibit a marked tendency towards a curvilinear direction.

Parallelism in the Palæozoic Groups of the two Continents.

Having enumerated the different systems of elevation which determined the structural relations of Europe, we now propose to ascertain how far they are applicable to North Amerioa. This is a task of much difficulty in reference to the older systems, since the geographical features are more complicated, and since the parallelism of particular groups, in the two regions, is still a matter of dispute. For this reason, probably, De Beaumont himself has refrained from making a direct application of his theory to this country ; he has merely glanced at

* Note sur les Systemes de Montagnes les plus anciens de l'Europe. 1847. Bul. de la Soc. Geol.

† James D. Dana, On the Origin of the Grand Outline Features of the Earth. Am Journal Science, vol. III., (2d series). 1847.

the general features, while to others belongs the task of tracing out the details.

Of the four older systems of upheaval, above enumerated, those of Westmoreland and Longmynd are the most important in European geology. As to the former, its age is satisfactorily determined, the elevation having taken place after the deposition of the Tile-stones, (which, according to the best authorities, is regarded as the crowning member of the Silurian), and before the deposition of the Old Red sandstone: thus establishing a well-marked line of division between the two systems of rocks, although De Beaumont and Murchison are disposed to merge them together. However important a landmark this may be in Europe, it is not applicable to this country, since the two systems present a succession of conformable strata.

The system of Morbihan, though next in order, is of little importance compared with that of Longmynd, since its age is determined by it. We shall therefore proceed to describe the latter.

The hills of Longmynd are composed of schists, upon whose upturned edges reposes the Caradoc sandstone; and hence the former were elevated before the deposition of the latter. This sandstone forms a well-defined geological horizon in England, where the Palæozoic series have been most thoroughly investigated; and it therefore becomes important to fix its American equivalent. De Beaumont regards the Caradoc sandstone as the equivalent of the Potsdam, which, in this country, rests at the base of the Palæozoic series, while in England there are members still below the Caradoc, which contain fossils. Hence, we would be led to infer that organic life started on the eastern continent at an earlier period than on the western—an inference which is not warranted by the facts.

Mr. Daniel Sharpe, an accomplished English palæontologist, to whom Mr. Lyell submitted his collection of American fossils,* while he admits that he has not been able to recognize as European, any species found in beds below the Trenton limestone, yet sees no ground for believing that any such beds have been discovered of an earlier age than the lower fossiliferous beds of North Wales—for instance, those in the neighborhood of Tremadoc—containing Lingulæ. De Beaumont assigns no reasons for regarding the Potsdam and Caradoc sandstones as iden-

* Quarterly Journal of Geological Society. London: 1848. Remarks on the Comparison of the North American Formations with those of Europe.

tical, whereas a comparison of the fossils would indicate that the latter was not older than the Hudson river group.

It is admitted that the Palæozoic series are developed in North America on a scale of grandeur and extent, not elsewhere observed. They are spread out in nearly horizontal beds, so that there can be no doubt as to the order of succession ; and their fossil contents are so little impaired, that their peculiar characters can be at once recognized. It would be an anomaly to suppose that the four thousand feet of fossiliferous rocks below the Caradoc, had accumulated in Europe before organic life started in America—an anomaly which we suppose, would hardly have escaped the far-seeing mind of De Beaumont. European geologists, in attempting to trace a parallelism between the rocks of the two countries, have undoubtedly been misled by the so-called Taconic system, embracing, as was supposed, a group of unconformable fossiliferous rocks below the Postdam sandstone—a system which we believe has no real existence. This imaginary system has been regarded as the equivalent of the Cambrian of Sedgwick, which includes most of the fossiliferous rocks below the Caradoc sandstones. De Beaumont may have hastily concluded that the Potsdam sandstone was contemporaneous with the Caradoc of England, and with that of Brittany and Scandinavia, since this rock occupies, in all of these regions, the base of the Silurian region—without weighing very carefully the Palæontological evidence, which, after all must decide the question. He was undoubtedly further confirmed in this opinion by the supposed analogy between the unconformability between the Taconic system and the Potsdam sandstone of America, and the unconformability between the schists of Longmynd and the Caradoc sandstone of Great Britain.

For the purpose of making a comparison between our own systems of upheaval and those of Europe, it will be especially necessary to fix, as nearly as possible, on the equivalency of the older systems of rocks in the two countries, since the age of the oldest systems of upheaval are determined by De Beaumont, principally by reference to certain groups as developed in England, Wales, and Brittany.

The following scheme is as accurate as could be expected, in the present state of geological knowledge. It would be impossible for us here to go into a critical examination of the data on which this parallelism is founded.

Parallelism of the Older Systems of Europe and America.

AMERICA.	EUROPE.
Azoic System.	
Crystaline schists, limestones and quartzose rocks, with intercalated traps of Lake Superior, etc.	Sandstones of Barmouth and Harlech, in Wales; island of Anglesia, England; gneissoid rocks of Scandinavia.
Lower Silurian.	
Potsdam sandstone; Calciferous sandstone.	The green slates and feldstones of Wales; The slates and porphyries of Bohemia; the lower sandstones of Scandinavia; the Obolus sandstone of Russia.
Chazy, Birds-eye, Black-river, and Trenton limestones.	Bituminous slates, and Orthocerate limestone of Russia.
Utica slate, and Hudson-river group.	Bala limestone of Wales; Llandielo flags and Caradoc sandstone of Great Britain.

The above comparison of the lower Silurian groups of the two continents seems to accord with the results of the geological survey of Wales. There, according to a communication of Barrande to the Geological Society of France, in which he gives the result of his own examination of the materials collected by the survey, the Caradoc sandstone is distinctly recognized as being between the upper and lower Silurian divisions, while the Bala limestone and the Llandeilo flags form the upper portion of the lower Silurian, corresponding with the Hudson river group in this country.

Four of the European systems are shown by De Beaumont to be prior in age to the deposition of the Caradoc sandstone, and we have enumerated three which are of at least as high antiquity in the region of Lake Superior. While, however, two of our systems are shown conclusively to be older than the palæozoic epoch, the age of the oldest European systems, with regard to the oldest strata containing organic life, is by no means so clearly settled.

In order, however, to institute a comparison between these oldest systems of Europe and those recognized by us, we have calculated the direction which they would assume if transferred to the region of Lake Superior.

1. The system of the Vendée; the direction of which, at Vannes, is N. 22° 30′ W. becomes—in longitude, 87° 30′ W., and latitude 47° 30′ N.,—N. 79° 53′ E.

2. The system of Finisterre; the direction of which, at Brest, is N. 68° 15′ E., becomes—in latitude 42° 22′ and longitude 72° 32′ W.—N. 38° 20′ W.

3. The system of Longmynd; the direction of which, at Binger-loch, is N. 31° 15′ E., becomes N. 53° 40′ W.

4. The system of Morbihan; of which the direction, at Vannes is N. 51° 45′ W., becomes N. 60° 30′ E.

On comparing these results with the directions of the systems of upheaval, before indicated as occurring in the Lake Superior region, we find that the direction of two of these systems coincides very nearly with that of two of those which have been calculated above.

The Lake Superior system agrees with the system of the Vendée; the former being about N. 80° E., S. 80° W., and the latter, transferred as above N. 79° 53′ E., S. 79° 53′ W.

With regard to the age of the system of the Vendée we quote the following from the last publication of Rivière on this subject: "I have united all the directions of the normal gneissoid rocks of the Vendée into one system of dislocations, to which I have given the name of the *system of the Vendée.* * * * * This is probably the most ancient normal system; at all events it is the oldest system known; if it was preceded by other systems these must be sought for in the north of Russia or in America, where the transition strata appear to be nearly horizontal. * * * The gneissoid formation is completely distinct from, and anterior to, the transition (Silurian or Cambrian) strata."

We may, therefore, presume that there is no doubt that both these systems, the European and American, are anterior to the deposition of the oldest fossiliferous strata, and thus far the agreement of each other in age and direction is sufficiently satisfactory.

The system of Kaministiquia, which seems to be the oldest which we have been able to recognize in America, appears to be older than any system of upheavals thus far admitted by de Beaumont. A coincidence will perhaps, be found, after farther observations shall have been made as to its precise direction in this country, and after the numerous systems of the azoic period in other regions shall have been worked out with clearness and precision. As the region to which this system is confined in this country lies without the limits of our district, we have not been able to fix its direction with the precision requisite for a comparison with those of other countries. Durocher, however, has recently announced the existence of six new systems of upheaval, in Scandinavia, older than the lower Silurian, or belonging to the azoic period. Besides these, he recognizes the existence there of the four oldest systems of de Beaumont, enumerated above. The data of direction and relative age of the new systems proposed by Durocher are so

indefinite, not having given the details, that we are without the means of comparison.

The system of Keweenaw Point agrees very nearly in its mean direction with that of Morbihan, of which the direction when transferred to the region of Lake Superior, becomes N. 60° 30′ E. The coincidence of this direction with that of Isle Royale had already been noticed by de Beaumont, who drew the inference that the sandstone and conglomerate of that island could not belong to the New red sandstone, as maintained by Dr. C. T. Jackson.

If, however, we proceed to inquire as to the coincidence in age of the system of Keweenaw Point and Morbihan, we find that there is good reason to suppose that they may belong to the same geological epoch. The elevation of the sandstones, conglomerate and bedded trap of the Lake Superior region appears to have taken place at a period not far removed from that of the deposition of the Hudson-river group. This is inferred from the position of the deposit of the lower Silurian near L'Anse, which appears to have been disturbed by the same causes which produced the elevation of the trap and conglomerate of Keewenaw Point. The age of the highest beds of this deposit is not more recent than that of the Hudson-river group, so that as far as can be known, this elevation must have taken place during the lower Silurian epoch.

According to de Beaumont, the age of the system of Morbihan is anterior to the deposition of the Caradoc sandstone and posterior to that of the Bala limestone. If it were admitted that the Caradoc sandstone is the equivalent of the Potsdam, we should be unable to recognize any agreement in the ages of the two systems in question. The age of the Caradoc sandstone, as well as that of the Bala limestone, seems at the present time to be better understood than when de Beaumont published the article before referred to, in which the ages of the older systems of elevation are so ably discussed.

If we consider as we are authorized to do by the most recent authorities, the Caradoc sandstone as forming the upper portion of the lower Silurian, and overlying uncomformably the Bala limestone, the next inferior member of the same group, we shall have a perfect correspondence in the age of the system of Morbihan in Wales, with that of Keweenaw Point in the Lake Superior region. As to the true position of the slates of Brittany,* there is some doubt, since the

* For most of the details incorporated in the subsequent part of this article we are indebted to our coadjudor, Mr. Desori.

two English champions have failed to come to an understanding. It does not seem settled that they are older, even, than the Caradoc. In reference to this point, De Beaumont remarks:—"The ancient schists of Brittanny are overlaid, unconformably, by a band of quartzose, conglomerate, and quartzite, which *appears to be* the equivalent of the Caradoc sandstone." Now, if we consider that there are numerous interstratified masses of sandstone and conglomerate in the Silurian system of North America, such as the Medina sandstone, Oneida conglomerate, and Oriskany sandstone, we would ask—What reason is there for regarding this quartzite as the equivalent of the Caradoc? May it not be a mere intercalated mass? The fossils mentioned by Sedgwick, (graptolites and fucoids), as occuring in the schists of Cumberland, are characteristic of the beds above the Trenton limestone of this country.

We have alluded to another assemblage of strata, known as the Bala limestone, which has been a stumbling block to most geologists who have undertaken to classify it. It would appear as though, in Wales, the same Caradoc sandstone which rests *unconformably* on the schists of Longmynd is, in other localities of the same district, underlaid *conformably* by extensive groups of fossiliferous rocks, among which is the Bala limestone. It was no easy task for the author of the elevatory theory to adapt these two groups to his system, in consequence of the position assigned to the Caradoc sandstone. Assuming, as he did, that the latter was the equivalent of the Potsdam, it irresistably followed, that the limestone of Bala was *ante*-Silurian. On the other hand, its unconformability with the schists of Longmynd would indicate that it was more recent than the latter: and, since these schists are considered as parallel with the Cumbrian, the consequence would be, that the Bala limestone must be intermediate between the Silurian and Cumbrian; a circumstance not recognized elsewhere. De Beaumont argues thus: "The fact that the Caradoc sandstone overlies, unconformably, the schists of Longmynd, does not imply that the former was deposited *immediately after* the upheaval of the latter; but should there be found, any where, a series of deposits, underlying *conformably* the Caradoc, the presumption would be that they immediately preceded it." Now, this is the case with the limestone of Bala; nevertheless, on account of its conformability with the Caradoc, De Beaumont refers it to the Silurian period, although he supposes it elsewhere, as in Brittany, to be separated from the Caradoc, by an upheaval contemporary with the system of Morbihan. This upheaval, therefore, took place

within the Silurian epoch, whereas the upheaval of Longmynd characterised its dawn. The order of events would be thus:—After the elevation of the schists of Longmynd, the sea, while retreating from the newly-raised lands, remained in the center of Wales, and there deposited the Bala limestone: during that period the system of Morbihan was raised; but, as it appears not to have operated very violently in Wales, it is assumed that the strata composing the Caradoc sandstone formed subsequently, though of different materials, might have been thrown down conformably on the preëisting deposits; whereas, over those areas where the effects of the upheaval were more marked, (for example, the hills of Longmynd), the subsequently-formed deposits would be unconformable.

However ingenious this theory, it is not applicable to the United States. Discarding the Taconic system, as having no real existence, and regarding the Caradoc sandstone and Bala limestone as contemporaneous with the Hudson river group, the difficulties are by no means formidable. This parallelism is authorized by the zoölogical resemblances; and Murchison himself has lately suggested that the Bala limestone might belong to the Llandeilo flags.

There are, however, distinctive features in the character of the formations of the two countries, which we can not fail to notice: the limited extent of the Bala limestone, and the scarcity of older fossiliferous deposits, indicating that, in Europe, the Palæozoic sea must have gone on increasing in extent, or, what amounts to the same thing, that there must have been a gradual subsidence of the land, which continued until the epoch of the Caradoc sandstone, when it attained its widest expansion. Nothing of this character has been observed on this continent. So far as we know, the lowest member of the Silurian system is spread over as extended an area as any of the succeeding ones; in fact, they are less extensively developed, which would seem to indicate that the Palæozoic ocean gradually decreased, from the epoch of the Potsdam sandstone; or, in other words, that the land was gradually rising, here, while it was subsiding in Europe.

As to the Appalachian system, De Beaumont was at first inclined to refer it to that of the Pyrennees, but now considers it as belonging, partly, at least, to the system of the Ballons, the direction of which is N. 74° W., but which, when transferred to the meridian of Washington, becomes N. 46° 42′ E.; a direction which almost exactly agrees with the outcrop of the principal ridges. There is, also, another direction to be noticed in the Alleghanies, which is nearly parallel with the

meridian, although, in many places, it becomes merged with the former. This is known as the *oldest meridional system* of Hitchcock; and is supposed by him to embrace the White Mountains of New Hampshire, and it would appear, he remarks, as though the strata had been deranged by the N. E. and S. W. system, which would go to show that the latter was more recent.*

De Beaumont remarks:—"I am inclined to think that it is older than the system of Ballons or Alleghanies; older than the oldest Silurian rocks of North America; even older than the system of Morbihan. It must, also, be older than the Taconic system, since the latter rests unconformably on the primary rocks of New Hampshire."

We can not subscribe to the high antiquity claimed for this meridional system. The age of the gneiss rocks, which compose it, has not been satisfactorily determined, but the probability is, that they are not older than the Lower Silurian. Its high antiquity is based on the supposition that it originated previously to the Taconic System, which is placed subordinate to the Silurian. We have before protested against recognizing this system in our geological speculations, as it will inevitably lead to error.†

*Geology of Massachusetts; p. 710.

† It is a remarkable fact, that no geologist, except its author, from actual observation, has succeeded in recognizing this system. Mr. Lyell and Prof. Hall passed over the ground of its supposed developements, in company with the discoverer; but, while they saw many instances of the inversion and folding of the strata, they satisfied themselves that the so-called Taconic system was not older than the Hudson river group. It is supposed to be located in western Massachusetts; but Prof. Hitchcock does not indorse it. In 1841, Prof. H. D. Rogers examined this region, and arrived at the conclusion that the crystalline marbles, and associated schists, and semi-vitrified quartz rock, of Berkshire, were the results of subterranean igneous agency; the first being regarded merely as the blue limestone of the Hudson valley, extensively altered, and the last a highly altered form of the white sandstone at the base of the Appalachian formations.—*Proc. Am. Phil. Soc. Jan.* 1841.

Mr. Logan, from the results of his observations on the structure of the Green Mountains, in their Canadian prolongation, infers that the whole, including the auriferous quartz veins, belong to the Hudson river group, with the possible addition of a part of the Shawagunk conglomerates. The succeeding micaceo-calcareous formation of Memphremagog lake, and St. Francis and Famine rivers, would seem to indicate that it was probably of an age not anterior to the Niagara limestone. This micaceo-calcareous formation has been traced, by Prof. Adams through Vermont, and thence it extends into Massachusetts. In Gaspé, an arenaceous formation succeeds the upper Silurian; the conditions of which appear to resemble those of the Portage and Chemung group, possessing a thickness of seven

The Messrs. Rogers maintain that the two directions of the Alleghanies have originated simultaneously, and are intimately connected with their whole composition. But, admitting that they are distinct in age, and discarding the existence of the so-called Taconic system, the Meridional system remains an anomaly, not only as to its age, but in its parallelism with any of the older systems of Europe.* On the whole, we see no ground for separating the so-called Meridional System from that of the Appalachian.

As for the Rocky Mountain system, its parallel is to be sought for in Asia, rather than in Europe. Erman states, that the great chain of Alden, in eastern Asia, which forms the water-shed between the river-systems of the Arctic and Pacific Oceans, if protracted in the direction of a great circle, or following the shortest course from point to point, would intersect several of the principal summits of the Rocky Mountains, between 40° and 45°; thus indicating that, though widely asunder, they belong to one great fissure.†

thousand feet: and it is not unreasonable to suppose that they should follow the upper Silurian zone in its south-west course, and display a conspicuous figure, either in a metamorphic, or unaltered condition, between the Silurian or Carboniferous areas of Eastern America; to one of which New Brunswick belongs, while another is met with in Rhode Island, and, in a metamorphic condition, in Massachusetts.—*Geol. Survey of Canada*, 1847–48; *pp.* 57 *and* 58.

We may add, that our own investigations in the Lake Superior district, prosecuted for more than a thousand miles along the base of the Potsdam sandstone, have convinced us that there are no older fossiliferous rocks below.

* De Beaumont, erroneously, as we think, ascribes to this system a very important part in determining the outlines of this continent. He undertakes to trace it from Greenland, through Labrador, to the mouth of the Hudson; thence to Cape Hatteras; thence, crossing the eastern portion of Cuba, it is supposed to intersect the Isthmus of Panama; and thence to touch the Cape of Guayaquil, and pass a little outside of the coast of Choco, in a direction parallel with the principal mountain chains of New Grenada. He considers it as among the most remarkable metalliferous zones of the globe, containing the gold mines of Vermont, Virginia, North and South Carolina, Georgia and Cuba; and also, the gold and platina mine of Hayti, and of Choco, and of the eastern Cordilleras of New Grenada.

Too much stress, we think, is here laid on the metalliferous character of rocks; but, adopting this as a test of the period of upheaval, we would remark, that Mr Logan has shown that the auriferous veins of Canada,—a prolongation of the auriferous veins of Vermont,—belong to the Hudson river group, while Humboldt and Murchison both concur, on independent grounds, in representing the impregnation of the rocks of the Ural with gold and platina, as among the most recent geological events.

† Reise um die Erde.

It is worthy of remark, that this chain, like the Rocky Mountains, is in many places, covered with volcanic materials, and several of the highest summits consist of active volcanoes. We have no information as to the character and age of the sedimentary strata which repose on its flanks.

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We have thus attempted to trace a parallelism between the mountain systems in the two hemispheres. We are disposed to regard these axes of elevation, not simply as irregular lines, of limited extent, but as possessing much uniformity in direction, and traversing entire continents; but, we admit, in the present state of geographical and geological knowledge, absolutely certain conclusions can not be attained. Our object has been to call the attention of American geologists to one of the most interesting problems in this science; one which, thus far, has not received the attention which it deserves. We have had another object in view: Many European physicists have represented this continent as being emphatically "new;" not simply in reference to its settlement and civilization, but to the period when it first emerged above the ocean. We have shown, conclusively, we think, that the period of its emergence was, at least, contemporary with, if not prior to, that of the eastern continent; although its outlines were very different from what we now behold.

In the succeeding epochs, we witness the operation of the same great forces, though not, perhaps, in all instances, simultaneously exerted in the two hemispheres. The seas swarmed with the same types of animal life, though not, in all instances, specifically identical, and the same forms of vegetable life clothed the land.

2. Notes on the Use of the Zenith Telescope in Determinig Latitudes in the Coast Survey, by Talcott's Method, and on the Reduction of the Observations. By A. D. Bache, Superintendent U. S. Coast Survey.

The method of determining latitudes, by measuring differences of meridian zenith distance of two stars, of nearly the same distance from, and on opposite sides of, the zenith, employed by Capt. Andrew Talcott, late of the U. S. Corps of Engineers, appears to me one of the most valuable improvements in practical astronomy of recent years. It has been described, with care, by Professor Courtenay, in the Journal of the Franklin Institute; by Major Emory, in his report of observations in connection with the north-eastern boundary of the United

States; and by Capt. Lee, of the U. S. Topographical Engineers, by whom it was repeatedly used in the operations of the Coast Survey.

The chief modifications in the instrument, since its introduction in the Survey, have been—in securing stability, by a brass arc, instead of a sliding rod, (proposed by Major Emory and by me); in increasing the facility of reaching the zenith, by raising the central columns, and somewhat diminishing the diameter of the azimuth circle; in substituting a single for a double micrometer; in providing a parallactic eye-piece; in illuminating by a lamp, not resting on the instrument; in bringing the divisions of the level and micrometer into just relations; in an adjustment for the verticality of the axis, (adapted by Mr. Simms, of London); and in providing stops to set the instrument in azimuth.

Quite a new form was proposed for the instrument, by the late R. H. Fauntleroy, one of the Assistants of the Coast Survey, in which the telescope was to be used for determining time; which it is capable of doing with sufficient precision for observations of latitude. The instruments of this kind used upon the Coast Survey, have been, generally, made by William Simms, of London; one has, however, been recently constructed by Mr. Würdemann, of Washington, and another is in progress of making, under Mr. Saxton's direction.

As used by us, the observations are made when each star is very nearly in the meridian, and as nearly as possible when passing the center of the field of the telescope. When there is a recorder to assist the observer, he calls out the setting of the instrument for each pair of stars, and when the star should enter the field; thenceforward calls each ten seconds, the observer following the star with the horizontal wire, and moving the instrument in azimuth, if it appears necessary, as the time of culmination approaches, to bring the star in the middle of the field. When within ten seconds, the recorder calls each second, and the instant of the previously computed culmination, when, the wire being upon the star, the first part of the observation is complete. The level and micrometer are read and recorded. The same process is repeated after the instrument has been turned 180° to observe the opposite star of the pair, on the other side of the zenith. A single observation on the meridian has, in our experience, been found preferable to several circum-meridian observations.

The form of record is not essentially different from that used by Captain Talcott, and by subsequent observers. By recording the readings of the level as N. and S. ends, instead of object and eye-ends, some trouble is saved. The table, with its headings, is as follows:

NUMBER I.

Form of recording Observations for Latitudes with Z. Telescope, Mt. Independence, (Black Strap,) Maine, Sept. 25,'49

STAR.	N. or S.	MICROMETER. Turns.	MICROMETER. Divis.	LEVEL. N.	LEVEL. S.	Time of observation by Chronom.	Time of culmination by Chronom.	MERIDIAN DISTANCE.	Coeff. red.	REDUCTION TO MERIDIAN.
						H. M. S.	H. M. S.			
6851	S	14	97.0	37.0	47.0	19 50 13	19 50 13			
6928	N	7	27.5	49.0	35.0	20 01 49	20 01 48			
6893	N	8	3.0	47.0	38.0	20 10 23	20 10 22			
6986	S	6	91.3	38.0	47.0	20 12 21	20 12 20			
7008	S	14	10.0	46.5	38.5	20 14 21	20 14 21			
7076	N	1	74.5	39.0	46.2	20 23 26	20 23 25			
								H. M. S.		
8076	S	11	60.0	50.0	35.5	23 03 15	23 03 05	*0 00 10	0.05	—1''.49
8115	N	2	98.5	37.5	48.0	23 10 27	23 10 27			

REMARKS.

Sidl. chron. 179 at 20*h*. 14*m*. 28.91*s*.
Slow 00h. 00m. 28s. 06.
Hourly rate gaining, 00.09*s*.
Commencement of obser.: Barometer 29.22; interior thermometer 63.3; exterior thermom. 62.7.

*Taken off the meridian.

Lat. = 43° 45′ 30″ cos = 9.85870
N. P. D. 47°15′ 32″ sin = 9.86594
Z. D. = 1° 01′ 02″ ar. co. sin. 1.75063

X=29.9 = 1.47527

Of the arrangement of the instrument in its place, and the simple adjustments it requires, when not employed to obtain time, it is not necessary to speak. We mount it, usually, on a block of stone, or wood, sunk about two feet in the ground, and find little advantage in one material over the other.

The instrument being in place, the first point is, to determine the value of the micrometer in angular measure. Several methods have been used for this purpose: the most common is, by turning the micrometer at right angles to the position in which it is generally used, and noting the number of divisions passed over by Polaris, or some other circumpolar star, in a given time, when near its culmination. Another method, introduced by Assistant C. O. Boutelle, is, to observe Polaris near elongation, when rapidly rising or falling, with but a slight motion in Azimuth. This is a pretty method, and avoids the displacement of the micrometer. When a theodolite is at hand, we generally obtain the micrometer values by the apparent diameter of a distant object, as measured in angular and in micrometer divisions, by the two instruments.

A ring of lead is placed around the sliding tube at the eye-end of the telescope, to prevent a change of focus. It is usual to test the different parts of the screw in obtaining these values, turning the micrometer both forward and backward. A record of a series of observations of the last-named kind is given, below, with their discussion:

NUMBER II.

Values of Micrometer Divisions, No. 1, by Distant Mark.

Date.	Distance from	With Micrometer.	With Theodolite.	Mic. value of one division.	$a \sim x$	$(a \sim x)^2$
		divis.	″	″		
May 16,	0 to S	1213.0=	463.1	.3818	.0004	.00000016
	0 " W	1324.0	503.2	.3800	14	0196
	0 " A	2845.0	109.6	.3852	38	1444
	Sums					

$e = 0.''0051 =$ probable error of a single observation.
E $= 0.\ 0012 =$ " " mean of all.
Mean value of one division of Micrometer $= 0''.3805 \pm 0''0012$

From these observations, a table is made, which, by simple inspection, shows the angular value of any number of turns of the screw, and parts of a turn. By suitably selecting the pairs of stars, any effect of inaccuracy in this determination may be avoided, by making the sum of the zenith distances, of all the pairs N. and S. of the zenith, zero. It is, generally, convenient to approach nearly to the fulfillment o this condition.

The value of the divisions of the level is next found in terms of the micrometer value; passing the bubble from one end to the other of the level, so as to detect and measure any irregularities. The telescope is pointed at a distant mark, or a collimating telescope is used; the displacement of the line of collimation, as the bubble of the level is made to travel from one end of the tube to the other, being measured by the micrometer. The advantage of the collimator, from the stillness of the air through which the observation is made, is shown in the following comparative results, by the two methods:

NUMBER III.

Value of Level Divisions. No. 1 by Distant Mark.

SERIES.	Level.		Micrometer.		Differ. Level.	Differ. Micr.	Value of one divis. of level in micr. divisions.
	O	E	Turns.	Divis.			
	64.5	14.7	0	0	4.25	19	4.47
	60.3	19.0	0	19	4.40	20	4.54
	56.0	23.5	0	39	5.50	21	3.82
	50.5	29.0	0	60			

$e = 0.5862$ in micr. divisions.
$E = 0.03275$ " "
Mean value of one division level $= 1''.5193$

No. 2 by collimator.

$e = 0.0770$
$E = 0.0181$

The value of the level divisions is then converted into arc, and a table prepared, which, by inspection, shows the correction to twice the latitude for an excess of sum of readings of north ends over sum of south ends, or *vice versa;* applying this correction in north latitude, with the sign N.—S. I constructed a table, from which the correction for level could be taken by inspection; the sum of the north end readings being arranged at the top, and the sum of the south end at the side—the correction being found on a diagonal line. It has not, however, found favor with the observers: but they usually prefer a table

of single entry, in which the argument is the difference of the series of north and south end readings, and opposite the correction in arc.

There are two corrections, which it may be as well to notice in this place; viz., for reduction to the meridian and refraction.

If the line of collimation of the telescope is off the meridian, the reduction to the meridian employed in altitude and azimuth instruments, and in sextant observations, applies. If the axis, or vertical wire, is in the meridian, and the star is observed before or after culmination, then the correction is such as is used with the zenith sector and with the meridian circle, viz: $x = -\frac{H^2}{4}$. Sin 2Δ, in which x is the correction, H the hour angle, and Δ the polar distance of the star.

These corrections were formerly tabulated, but now are generally avoided by the mode of observing, and the cases in which they occur are computed separately. In general, the tendency is to avoid methods which introduce tedious calculations, unless attended with decided advantage.

One of the great advantages of Talcott's method is, that the correction for refraction is very small; being for the difference, merely, of the two refractions on each side of the zenith. The correction for temperature and pressure of the air is, usually, insignificant; amounting, at the distance of 25° from the zenith, and for a difference of 20 minutes of zenith distance, two inches of the barometer, and 50° of the thermometer, (Fahr.), to only 0.″02. The whole correction for refraction is obtained by the following easy method, first used, I believe, by Prof. Gibbes, of Charleston: The refraction being nearly proportional to the tangent of the zenith distance, the differences for the two stars of the pair will be nearly the differential of the tangent of the zenith distance of the star south of the zenith, and will be inversely proportional to the square of the cosine.

Call Zs the true zenith distance of the star south of the zenith, and Zn the same for the star north of the zenith.

Then in each case the true zenith distance = the observed distance + the refraction, which is proportional to the tangent of the zenith distance;—or calling Zs_0 and Zn_0 the observed zenith distance of the star S and N of the zenith,

$$Zs = Zs_0 + m \tan Zs, \text{ and}$$

$$Zn = Zn_0 + m \tan Zn$$

$$Zs - Zn = Zs_0 - Zn_0 + m\,(\tan Zs - \tan Zn.)$$

Since $\tan Zs - \tan Zn = \tan (Zs - Zn)\,(1 + \tan Zs \tan Zn)$ a table may easily be rigorously computed, or approximately,

$$d \tan Zs = \frac{dZs}{\cos^2 Zs}$$

And the log correction is Log $\dfrac{m \sin 1'' \text{ diff. zen. dist.}}{\cos^2 Zs}$, from which a table is easily constructed.

The following table for correction for refraction to the nearest hundredth of a second, for different zenith distances and differences of zenith distance, has been computed by this method, by sub-assistant G. W. Dean, of the U. S. Coast Survey:

[B.]

Cor'ns for Refraction, to be used in correcting obser's. with Z. Tel.

MICRO-METER ARC.	ZENITH DISTANCES.										
	0° 30′	°0 40′	9° 40′	13° 00′	15° 40′	17° 50′	19° 40′	21° 20′	22° 50′	24° 10′	25° 25′
0′ ″	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
30	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
1	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
30	.02	.02	.03	.03	.03	.03	.03	.03	.03	.03	.03
2	.03	.03	.03	.04	.04	.04	.04	.04	.04	.04	.04
30	.04	.04	.04	.04	05	.05	.05	.05	.05	.05	.05
3	.05	.05	.05	.05	.05	.06	.06	.06	.06	.06	.06
30	.06	.06	.06	.06	.06	.06	.07	.07	.07	.07	.07
4	.07	.07	.07	.07	.07	.07	.08	.08	.08	.08	.08
30	.08	.08	.08	.08	.08	.08	.09	.09	.09	.09	.09
5	.08	.08	.09	.09	.09	.09	.10	.10	.10	.10	.10
30	.09	.09	.10	.10	.10	.10	.10	.11	.11	.11	.11
6	.10	.10	.10	.11	.11	.11	.11	.12	.12	.12	.12
30	.11	.11	.11	.12	.12	.12	.12	.13	.13	.13	·13
7	.12	.12	.12	.12	.13	.13	.13	.14	.14	.14	.15
30	.13	.13	.13	.13	.14	.14	.14	.15	.15	.15	.16
8	.14	.14	.14	.14	.15	.15	.15	.16	.16	.16	.17
30	.14	.14	.15	.15	.16	16	.16	.17	.17	.17	.18
9	.15	.15	.16	.16	.16	.17	.17	.18	.18	.18	.19
30	.16	.16	.17	.17	.17	.18	.18	.19	.19	.19	.20
10	.17	.17	.17	.18	.18	.19	.19	.20	.20	.20	.21
30	.18	.18	.18	.19	.19	.20	.20	.21	.21	.21	.22
11	.19	.19	.19	.20	.20	.20	.21	.21	.22	.22	.23
30	.19	.20	.20	.21	.21	.21	.22	.22	.23	.23	.24
12	.20	.20	.21	.21	.22	.22	.23	.23	.24	.24	.25
30	.21	.21	.22	.22	.23	.23	.24	.24	.25	.25	.26
13	.22	.22	.23	.23	.24	.24	.25	.25	.26	.26	·27
30	.23	.23	.24	.24	.25	.25	.26	.26	.27	.27	.28
14	.24	.24	.24	.25	.26	.26	.27	.27	.28	.29	.29
30	.25	.25	.25	.26	.27	.27	.28	.28	.29	.30	.30
15	.25	.26	.26	.27	.27	.28	.29	.29	.30	.31	.31
30	.26	.26	.27	.28	.28	.29	.30	.30	.31	.32	.32
16	.27	.27	.28	.29	.29	.30	.31	.31	.32	.33	.33
30	.28	.28	.29	.30	.30	.31	.32	.32	.33	.34	.34
17	.29	.29	.30	.30	.31	.32	.33	.33	.34	.35	.35
30	.30	.30	.31	.31	.32	.33	.33	.34	.35	.36	.36
18	.31	.31	.31	.32	.33	.34	.34	.35	.36	.37	.37
30	.31	.32	.32	.33	.34	.35	.35	.36	.37	.38	.38
19	.32	.32	.33	.34	.35	.36	.36	.37	.38	.39	.40
30	.33	.33	.34	.35	.36	.36	.37	.38	.39	.40	.41
20	.34	.34	.35	.36	.37	.37	.38	.39	.40	.41	.42
30	.35	.35	.36	.37	.38	.38	.39	.40	.41	.42	.43
21	.36	.36	.37	.38	.38	.39	.40	.41	.42	.43	.44
30	.36	.37	.38	.38	.39	.40	.41	.42	.43	.44	.45
22	.37	.38	.38	.39	.40	.41	.42	.43	.44	.45	.46
30	.38	.38	.39	.40	.41	.42	.43	.44	.45	.46	.47
23	.39	.39	.40	.41	.42	.43	.44	.45	.46	.47	.48
30	.40	.40	.41	.42	.43	.44	.45	.46	.47	.48	.49
24	.41	.41	.42	.43	.44	.45	.46	.47	.48	.49	.50

The same table may be formed as conveniently by differences from the usual refraction tables.

In selecting the pairs of stars for use with this instrument, we have found the following rules convenient or necessary to be observed. The British Association Catalogue has afforded ready means for their selection, and the computation of their places.

1. The latitude of the place is assumed to the nearest two or three minutes of arc.

2. The zenith distances should be as small as practicable (the instruments now used admit of ready access to the zenith in observations), and should not extend beyond twenty-five degrees.

3. The differences of zenith distance should be small, and in no case exceed a convenient range of the micrometer, say, ten minutes of arc, corresponding (in the instruments which we use) to about thirteen turns of the micrometer.

4. The interval of time between the culmination of the stars of a pair should not be less than one minute; so as to give time deliberately to read the micrometer, and to turn the instrument in azimuth, to be prepared for observation; and should not exceed about twenty minutes, to avoid changes in the instruments.

5. The interval between the pairs should afford time for reading the micrometer and level, and for setting the instruments for the next pair. This will vary with different observers; but three minutes is about the time adopted by most of our observers. When the intervals between pairs are unavoidably long, they are filled up by observing transits for time.

6. The VI$\frac{1}{2}$ magnitude is the least that admits of easy observation, with the telescopes which we use. They are by Simms of London, have a focal length of forty inches, and object-glasses about three inches in diameter; and we commonly observe with a magnifying power of fifty or sixty.

7. In selecting pairs, all stars marked "doubtful," are rejected; in general, those having but one authority are not taken. Experience has induced an exception in the case of those marked G, (Groombridge), in the British Association Catalogue.

8. In order to be certain to embrace all desirable combinations, the catalogue is to be consulted from the earliest AR which the daylight, at the time of beginning the series of observations, permits, to the latest hour at which it is desirable to observe. Within this period of AR, the stars are divided into belts by their declinations; the breadth

of each being equal to that of the field of the instrument, and being paired accordingly, the corresponding declinations north and south of the zenith, as in the following table for Mount Independence, near Portland, Maine; assumed latitude, 43° 45′, and field of the telescope 15′:

TABLE NO. I.

For Selection of Pairs for Observation with Zenith Telescope.

No. of Star in B. A. C.	N. or S.	Mag.	Auth.	A. R.	N. P. D.
				h. m. s.	46° 00′ and 46° 30′
5997	S	VI	1	17 36 05	46° 27′ 14″
6095	"	"	1	17 53 25	46° 34′ 04″
6162	"	"	1	18 02 57	46° 33′ 16″
6720	"	"	1	19 29 59	46° 22′ 56″
7241	"	V½	3	20 44 45	46° 30′ 14″
7681	N	VI	1	21 56 53	46° C4′ 18″

(15′ each side of zenith.)

No. of Star in B. A. C.	N. or S.	Mag.	Auth.	A. R.	N. P. D.
				h. m. s.	45° 45′ and 46° 45′
6013	N	VI	1	17 38 39	45° 50′ 53″
6728	S	V½	1	19 31 46	46° 37′ 40″
6731	N	VI	1	19 31 59	45° 38′ 02″
7317	N	"	1	20 57 02	45° 47′ 55″
7333	S	IV	3	20 59 28	46° 40′ 06″
7402	S	VI	2	21 12 52	46° 40′ 59″
7705	N	"	3	21 59 56	45° 42′ 51″

The table is continued, as above, until 20° to 25° from the zenith is reached. It contains the information necessary to apply the foregoing rules for selection. The pains which may be bestowed on this table are not lost. Some of the observers prefer, in filling it up, to take zones of five degrees at a time, on each side of the zenith, and to go through the catalogue thus, several times within the limits of the AR determined upon.

The pairs, then, are selected, and placed according to the right ascensions, as in the following table:

TABLE NO. II.

For Selection of Pairs for Observation with the Zenith Telescope. From 17h. to 19h.

Stars.	N. or S.	Mag.	Auth.	AR.			N. P. D.		
6238	S	VI	3	18h	15m	10s	61°	11′	52″
6289	N	V	3	18	21	43	31	17	07
6179	N	III½	3	17	50	56	33	06	09
6147	S	V½	3	18	01	20	59	27	23
6178	S	V	3	18	06	10	58	37	40
6184	N	VI	1	18	07	21	33	45	58
6368	N	VI	2	18	35	35	34	53	24
6427	S	VI	3	18	44	17	57	37	07
6091	N	II	5	17	53	08	38	29	29
6235	S	IV½	3	18	14	37	53	59	59

From 19h. to 21h.

Star.	N. or S.	Mag.	Auth.	AR.			N. P. D.		
				h.	m.	s.	°	′	″
7008	S	VI	1	20	14	49	51	04	03
7076	N	VII	3	20	23	53	41	34	42
6983	N	IV½	3	20	10	50	42	44	38
6996	S	V½	2	20	12	48	49	43	59
7277	S	IV	3	20	57	35	49	24	29
7301	N	V½	3	20	54	43	43	03	45
7100	S	VI	1	20	27	39	47	19	05
7177	N	I	5	20	36	19	45	15	12
7317	N	VI	1	20	57	03	45	47	55
7333	S	V	3	20	59	29	46	40	06
6851	S	V	3	20	50	41	55	18	47
6928	N	V½	1	20	02	16	37	16	42
6932	N	V	3	20	03	09	28	26	20
6944	S	VI	3	20	05	43	63	57	55
7001	S	VI	1	20	13	30	51	27	48
7062	N	V½	3	20	22	27	41	06	45
7132	S	V½	4	20	31	27	58	59	51
7189	N	VI½	2	20	38	33	33	09	09
6571	S	VI	2	19	06	01	58	57	45
6583	N	V	3	19	08	50	33	23	41

NUMBER III.

Pairs Selected for Observation.

No. of Pair.	Star.	N. or S.	Mag.	Auth.	AR.	N. P. D.	Δ+Δ′	Z—Z′	ZD.
					h. m. s.	° ′ ″			
	6109	N	VI	3	17 55 39	44 29 23	92°	1″	1° 46′
1	Time μ′ Sagittarii at				18 04 46				
	6203 ..	S	VI	1	18 10 59	47 53 21	22′ 44″	—6 16	1° 38
	Time α Lyrae .				18 31 51				
	Time 6599 ...				19 11 09				
	Time δ Aquilæ				19 17 55				
2	6681	N	VI½	3	19 23 04	32 16 29	27 53	—1 07	13 59
	6740	S	IV	3	19 33 27	60 11 24			13 56
3	6771	S	V	3	19 38 53	53 00 19	30 19	+1 19	
	6865	N	VI	1	19 52 38	39 30 00			6 45
4	7001	S	VI	1	20 13 29	51 27 51	34 39	+5 39	5 12
	7062	N	V½	2	20 22 27	41 06 48			5 09
5	6937	S	V	3	20 03 51	53 35 56	35 08	+6 08	7 20
	6959	N	V	1	20 08 22	38 59 12			7 16
	Time 61, Cygni				21 00 11				
6	7398	S	IV½	4	21 11 31	51 13 58	21 23	—7 37	4 59
	7411	N	VI	1	21 14 18	41 07 25			5 08
	Time β Aquarii				21 23 39				

From the table No. II., the pairs which best fulfil the conditions heretofore stated, are selected, and the difference between twice the co-latitude of the place and the sum of polar distances, is entered with its proper sign, $\left(180°—2\,L—(\Delta_n+\Delta_s)\right)$ this quantity being equal to the difference of the zenith distances of the two stars composing the pair, (since $180°—2\,L=\Delta_n+\Delta_s+Z_n—Z_s$. L. being the latitude Δ_n and Δ_s the polar distances of the star N. and S. of the zenith respectively, and Z_n' and Z_s the zenith distances of the same star.

The object of obtaining the zenith distances approximately, is, so to select the pairs that the sum of all their differences, with their proper

signs, shall be nearly zero; which, as before stated, corrects for any error in the determinations of the micrometer values which are used in the observations.

$$\Sigma Z - \Sigma Z^1 = 2' \ 41''$$ for 17 pairs.

No. of Pair.	Star	N.or S.	Mag.	Auth.	AR.	N. P. D.	Δ + Δ'	Z—Z'	ZD.
					h. m. s.	° ' "		' "	
1	6109	N	VI	3	44 29 25	44 29 23	92°		1° 46'
	Time, μ' Sagittarii at					18 04 46			
	6203	S	VI	1	47 53 21	47 53 21	22'.44"	—6 16	
	Time, α Lyrae				18 31 51				
	Time, 6569				19 11 09				
	Time, δ Aquilæ ...				19 17 55				
2	6681	N	VI½	3	19 22 04	32 16 29			
	6740	S	IV	3	19 33 27	60 11 24	27—53	—1 07	13 56
3	6771	S	V	3	19 38 53	53 00 19			
	6836	N	VI	1	19 52 38	39 30 00	30 19	+1.19	
4	6937	S	V	3	20 03 51	53 35 56			
	6959	N	V	1	20 08 22	38 59 12	35 08	+6 08	
5	7001	S	VI	1	20 13 29	51 27 57			7 20
	7062	N	V½	2	20 22 27	41 06 48	34 39	+5 39	7 16
	Time, 61, Cygni,				21 00 11				
6	7398	S	IV½	4	21 11 31	51 13 58			4 29
	7411	N	VI	1	21 14 18	41 07 25	21 23	—7 37	5 08
	Time, ζ Aquarii,				21 23 39				
7	7598	N	V	3	21 40 15	41 23 03			4 52
	7614	S	VI	1	21 44 52	51 09 56	32 59	+3 59	4 54
8	7803	S	VI	1	22 15 38	47 00 51			0 45
	7894	N	VI½	3	22 31 48	45 35 50	36 27	+7 27	0 40
9	153	N	IV	3	00 28 38	36 55 50			9 20
	158	S	VI	3	00 29 20	55 25 43	21 34	—7 26	9 10
10	226	N	VI	1	00 41 13	43 03 18			3 12
	288	S	VI	3	00 54 29	49 27 54	31 12	+2 12	3 12
11	318	S	V	3	00 59 25	46 51 35			0 36
	352	N	VI	3	01 03 54	45 27 50	19 25	—9 35	0 47
12	487	N	III½	3	1 28 48	41 08 06			4 07
	5012	S	V	3	1 31 44	50 11 13	19 19	—9 41	3 56
13	649	S	V½	3	1 59 27	52 51 20			6 36
	673	N	V½	3	2 03 38	39 38 07	29 27	+0 27	6 37
14	706	N	V	3	2 09 37	43 18 55			2 57
	727	S	V	3	2 13 31	49 17 18	36 13	+7 13	2 02
15	819	N	VI	1	2 32 26	37 07 08			9 08
	877	S	V½	3	2 42 16	55 33 47	40 55	+11 55	9 18
16	915	S	V½	2	2 49 45	55 25 27			9 10
	947	N	III½	3	2 53 57	37 05 11	30 38	+1 38	9 10
17	953	S	IV	3	2 55 34	51 44 44			5 29
	1043	N	II½	4	3 13 37	40 40 42	25 26	—3 34	5 35

Sum + 47' 57"
" — 45' 16"
ΣZ—ΣZ' = + 2' 41"

The places of the stars are next accurately worked up by the method laid down in the preface to the B. A. C.

The forms used for computing the observations with the zenith telescope are shown, in the annexed tables. There are briefer methods; but this one has the advantage that all the quantities are spread out in the table, so that a second computer (the office computer) who differs from the first (the field computer) may trace, readily, the source of discrepancy.

DATE.	No. * B. A. C.	N or S.	Micrometer Turns	Micrometer Divis	Diff. Z.D. By Mic.	Diff. Z.D. Arc.	1800—Sum of Polar Distances.	Twice Approx. Lat.	Levels. N.	Levels. S.	State of lev'l	Merid Dist.	Red to Merid.	CORRECTIONS. Level.	CORRECTIONS. Merid.	CORRECTIONS. Refrac.	Twice lat.	Latitude.
1849.	6983	N	5	30.2			42 44 20.04		58.0	34.6								
Sept. 20	6996	S	4	15.0			49 43 41.46	87°	37.0	55.6							87° 30′	43° 45′
					—115.2	—0′ 51″.86	92 28 01.50	30 66.64	95.0	90.2	+4.8			+2.15		—0.02	68 77	34″.39
							87 31 58.50											
	6983	N	4	91.5			42 44 19.87		45.1	46.2								
" 21	6996	S	3	85.3			49 43 41.30		41.2	50.2								
					—106.2	—0′ 47.81	92 28 01.17	30 71.02	86.3	96.4	—10.1			—4.54		—0.02	66 46	33″.23
							87 31 58.83											
	6983	N	8	3.0			42 44 19.30		47.0	3.80								
" 25	6996	S	6	91.3			49 43 40.79		38.0	47.0								
					—111.7	—0′ 50.29	92 28 00.09	30 69.62	85.0	85.0	—0.0			—0.0		—0.02	69 60	34″.80
							87 31 59.91											
	6983	N	5	88.8			42 44 19.04		41.0	56.0								
" 27	6996	S	4	79.0			49 43 40.56		57.0	40.0								
					—109.8	—0′ 49.43	92 27 59.60	30 70.97	98.0	96.0	+2.0			+0.90		—0.02	71 85	35″.92
							87 32 00.40										Mean =	34″.58

In discussing the results of the observations, the first step is to ascertain the probable error of observation. For this purpose, the latitude which results from each observation, on each pair of stars, is compared with the mean latitude, from all the observations on that pair. If the observations were numerous, of course the probable accidental error would be thus obtained with more precision than in the actual case.

The following table gives a convenient form for applying this method. The results were obtained by one of the sub-assistants in the U. S. Coast Survey, at Mount Independence, with the Zenith Telescope of the Coast Survey, No. 3.

For Probable Error of a Single Observation.

No. of Pairs.	Results for Lat.	x	$(a-x)$	$(a-x)^2$	SUMMARY.	
I	37.92					
					I, II, III, IV, sum of sqs.	10.9907
	35.71		1.79	3.2041	V, VI, VII,	10.5131
II	33.01		.91	.8281	VIII, IX, X,	6.0435
(4)	32.90		1.02	1.0400	XI, XII, XIII, XIV,	8.5117
	34.05		.13	.0169	XV, XVI, XVII, XVIII,	6.7534
		33.92			XIX, XX, XXI, XXII,	7.8312
	36.15		.05	.0025	XXIII, XXIV, XXV, XXVI,	7.3678
III	37.84		1.64	2.6896	XXVI, XXVII, XXVIII,	5.5054
(4)	34.59		1.61	2.5921	XXIX, XXX, XXXI,	6.9242
	36.23		1.03	.0009	XXXII, XXXIII,	2.3263
		36.20				
	42.41		.67	.4489	$\Sigma\,(a-x)^2 =$	72.7673
IV	41.44		.36	.0900		
	41.50		.24	.0576		
(4)	41.60		.14	.0196		
		41.74				
	31.97		.28	.0784		
V	32.80		.55	.3025		
(5)	32.55		.30	.0900		
	31.44		.81	.6561		
	32.48		.23	.0529		
		32.25				
	29.81		1.39	1.9321		
	28.22		.20	.0400		
VI	28.11		.31	.0961		
(5)	26.72		1.70	2.8900		
	29.24		.82	.6724		
		28.42				
	34.39		.19	.0361		
	33.23		1.35	1.8225		
VII	34.80		.22	.0484		
	35.92		1.34	1.7956		
(4)		34.58				
				21.5038		

Number of observations, $x = 150$

" " pairs, $v = 32$ $\quad m^2 = \Sigma\left(\dfrac{a-x}{x-v}\right)^2 = \dfrac{72.7673}{118} = 0.6167$

$x - v = 118$

Then $0.6167 = \Sigma\,(a-x)^2$ on a single pair having but a single observation upon it.

The probable error of one observation $= \sqrt{.4549 \times 0.6157} =$ $0''.53$

" " " " the result of a pair having three observations upon it, ... 0.31

For four observations upon a pair, ...	0.27
" five " " "	0.24
" six " " "	0.22
" seven " " "	0.20

From this, results the mean probable error of any number of observations upon a pair of stars, by dividing the value just found by the square root of the number of observations.

We are now prepared to estimate the error of the places of the stars used; for the discrepancies which they show are composed of errors of observation and of errors of the catalogue, if the computations have been rightly made. The form in which this discussion is made is given in the annexed table, with the results:

Number of Pairs.	No. of Star in B. A. Catalogue		Mean of each pair. x	Mean latitude. a	$a \sim x$	$(a \sim x)^2$
I	6368	6427	37.92	34″.50	3.42	11.6964
II	6497	6522	33.92		.58	.3364
III	6571	6583	36.20		1.70	2.8900
IV	6673	6712	41.74		7.24	52.4176
V	6745	6754	32.25		2.25	5.0625
VI	6851	6928	28.42		6.08	36.9664
VII	6983	6996	34.58		1.23	.0064
VIII	7008	7076	33.27		.08	1.5129
IX	7100	7171	34.55		.05	.0025
XXXIII	953	1043	35.12		.62	.3846
		33	1138.66	$\Sigma\,(a-x)^2$		169.6906
Mean lat. = 43°45′			34″.50		$\Sigma\,M^2$	4.4418
					Diff......	165.2488

For $x-1$ pairs.

$$e^2 \text{ Catalogue} = \frac{\Sigma\,(a-x)^2 - \Sigma\,M^2}{x-1} = \frac{165.2488}{32} \quad \begin{array}{l} \text{Log.} = 2.21814 \\ \quad\text{"} \;\; = 1.50515 \end{array}$$

$$0.71299$$

$$.4549 \quad \text{"} = 9.65792$$

$$e^2 \text{ Cat.} = 0.37091$$

$$e \text{ Cat.} = 1''.53 = 0.18545$$

Probable error of position of one pair of stars, as given in B. A. Catalogue, = 1″.53

The omission of the observations on the four pair of stars having the greatest probable error, would reduce the average Catalogue error of each pair to $0''.95$, and alter the mean latitude but $0''.5$. The omission of five pairs, having the next greatest probable errors, would but slightly change the probable error of the Catalogue, (to $0''.93$), while it would affect the mean latitude $+0''.32$. The effect of a few very discordant results on the probable error is not peculiar to these results, or confined to this class of observations.

A general comparison of the results obtained in the Coast Survey,—as I propose, on some other occasion, to show,—confirms the conclusion here deduced, that the weak point of this method is in the Catalogue places of the small stars used. The steps which have been taken to obtain determinations of these, in connection with the Survey, I hope, also, to bring before the Association. In the meanwhile, we multiply the number of pairs of stars, and make a number of observations on each pair; which would keep our results in due relation to those of the Catalogue, if much more perfect than at present.

3. On the Palæontology of the Lowest Sandstones of the North-West. By D. D. Owen.

The occurrence of highly fossiliferous strata, much lower in the geological formations than had been previously observed in the West, is one of the most interesting facts connected with the palæontology of the Upper Mississippi and its tributaries in Wisconsin and Minnesota.

This discovery, which throws an entirely new light upon the zoological character of the oldest fossiliferous beds of the West, was made in 1847, during the first year of the survey of that country.

Leaving out of view, for the present, the, as yet, problematical Taconic System, only two species of Lingulas had been discovered, up to that time in this country, in strata of the age of the Potsdam sandstone, with perhaps an associated Orbicula, and some obscure bodies, referred to a sub-genus of frecoides, and noticed in the reports under the name of *Scolithus*. These were considered the oldest fossils then discovered in the United States; so that Mr. Hall, in his preface to the Palæontology of New York, p. 18, after remarking on this fact, says: "We find ourselves forced, therefore, to commence our comparisons with European formations, from the Trenton limestone.

In August, 1847, while descending the St. Croix, I observed multi-

tudes of *Lingulas* and *Orbiculas* disseminated in strata abutting against the south-west side of the trap range that crosses that stream at its falls. In tracing out the geological position of these beds during the succeeding months of the same year, they were found to be only a portion of highly fossiliferous beds, lying toward the base of the lowest sedimentary strata, that rest and abut upon the igneous rocks of that country; all of which occupied a geological position beneath the Lower Magnesian limestone, containing *Ophileta* and other fossils of the Calciferous sandstone group of New York.

At the same time, it was observed that *Lingulas and Orbiculas* were by no means the only genera characterizing these rocks, but were accompanied by other bracheopa, and several forms of crustacea, some of which could be traced down six hundred to seven hundred feet below the bottom of the Lower Magnesian limestone, and even beneath Lingula beds, containing apparently *Lingula prima* and *Lingula antiqua* that characterize the lowest fossiliferous beds of the Potsdam sandstone of New York.

In October of the same year, while measuring and examining the sections on the Mississippi, between the Falls of St. Anthony and the mouth of the Wisconsin river, I found beneath Lingula grits of this description, finer grained and more laminated soft sandstones, with subordinate Silico-Calcareous layers, charged with *Obolus,* like those which characterize the lowest sandstones of Russia. In some of the very lowest of these beds, within one or two feet of low water mark, ten miles below Mountain Island, and near the point where the rocks of the Upper Mississippi attain their greatest elevation above that stream, I succeeded in discovering a peculiar trilobite, remarkable on account of the spines with which it was provided, projecting backwards from the pygidium, a figure of which was given in the report of 1848.

The examinations of this year fully convinced me that the formations of Wisconsin and Iowa were destined to divulge new facts regarding the organic remains of the oldest sedimentary strata of this country. Impressed with this belief, minute stratagraphical and palæontological sections were undertaken in 1848 and the subsequent years of the survey, by myself and the members of the corps engaged in the surveys, where the protoyric rocks extended, and every locality visited and examined, that promised to throw light on the subject. These combined labors finally developed beneath the Lower Magnesian limestone, at least six different trilobite beds, separated by from ten to one hundred and fifty feet of intervening strata.

After having communicated this fact in general terms, in my preliminary report, written at Prairie du Chien, on the 11th of October, 1847, and which was subsequently published in the report of the Secretary of the Treasury, early in the following season; and again noticed the subject, much more in detail, in the report of our operations in 1848, and published in the spring of 1849, with accompanying figures of some of these fossils, I was not a little surprised to see a short notice of these interesting developments in the annual of Scientific Discovery for 1850, without the least reference to these accounts, published two years previously; the more especially as these observations had been recorded with the proper credit in the Bulletin of the Geological Society of France for 1848 and 1849.

The largest genus of trilobites obtained in this formation, to which the name of *Dikella-Cephalon* has been given, occurs a few feet above the water level on the west bank of Lake St. Croix, imbedded in a kind of hydraulic limestone, one of the uppermost of these beds. In form it approaches nearest to Ogygia, but differs from it in several essentials, especially in the structure of the pygidium, the axal lobe of which is not so prolonged, and has much fewer articulations; the axal lobe, too, is circumscribed by an extended marginal flap, instead of a narrow border, as in Ogygia. This is formed by the union of the lateral and interlateral sequents. Two spears project from the posterior margin of the flap.

This latter character seems to have been peculiar to several of these ancient trilobites. Similar caudal appendages, of considerable length, and much attenuated, are well displayed in some of the specimens collected from the lowest trilobite grits, that lie thirty to forty feet below the coarse Lingula grits of Mountain Island, and opposite the mouth of Black river, associated with vast numbers of Obolus and minute Lingulas of different species from those in the higher, coarser grits. This, which is the lowest of all the trilobites at present observed, has fewer segments, both of the middle and lateral lobes of the pygidium, than the large species from Lake St. Croix.

Numerous aphalic and caudal shields of other trilobites, occur in soft grits at the mouth of the Mineska river. The form of the glabella of the largest of these, bears a considerable analogy to that of the *Dikella cephalon*; it differs, however, in the size and shape of the expansion of the cheeks in front of the glabella, which is much narrower, and bent downward, instead of curving slightly upward at the margin.

The same grits contain another species, which differs from the above

in the distinctness of the anterior transverse furrow of the glabella; also, in the surface of the cephalic shield being studded with tubercles. Another tuberculated species occurs in the same rock. The specimens obtained are, however, imperfect. There is only sufficient of the cephalic shield seen, to show that it is much more highly arched than the preceding.

The Menominie trilobite grit, situated about forty or fifty feet above the lowest trilobite bed, is characterized by a minute species of trilobite, chiefly remarkable on account of a spinous appendage, which has its origin at an angle in the middle of the posterior part of the glabella, and projects upward and backward in the median line of the body. The glabella in this species has only one distinct transverse furrow, immediately in rear of the origin of this spinous process.

To convey an idea of the abundance of this species in the grits of the Menominie river, it may be stated that on a specimen measuring three inches square, more than a hundred individuals can be counted. The outlines of the impressions are sharp and well-defined; unfortunately, however, the cephalic and caudal shields of these trilobites are mostly detached from the thoracic segments, which latter are seldom preserved; the wing shield, too, is generally separate from the glabella. This renders the study of these ancient trilobites difficult, especially as, in the pure gritstones, they are mostly casts of the inner surface of their shelly covering.

In 1849, Dr. Shumard found in Green sandstones, above the level of of the Mississippi, near the head of Lake Pepin; and also on the Wisconsin river, the remains of Crinoidea. This encrinital bed lies some forty feet below the St. Croix trilobite bed.

Specimens of both Orthis and Spirifer occur at a lower level between these crinoidal beds and the Mineska trilobite grits.

A fuller description of these various species of trilobites, which belong, probably, to more than one genus, is in course of preparation for the final report on the Geology of the North-west. The object of this short notice is merely to show, in connection with the specimens exhibited, that crustacea do actually occur in Wisconsin, Iowa, and Minnesota, even as low down in the unaltered sedimentary strata, as any organic relics have yet been traced; and that the oldest sandstones of that country contain also *Sporifer, Orthis, Obolus,* and remains of crinoidea, besides *Lingulas* and *Orbiculas.*

4. On a Modification of Apparatus for the Registration of Time for Astronomical Purposes. By Wm. Wurdeman, of Washington. (In a letter to Professor Henry.)

Washington, April 29, 1851.

Prof. Joseph Henry, Secretary of Smithsonian Institution: When you favored me with the order for a register of time, to be attached to the Kessels clock, you left me unrestricted as to the kind or the manner of construction to be adopted. The desideratum of a perfect mechanical time register, having of late grown to be a matter of considerable importance, so as to occupy the minds of men well known to the scientific world, I gladly seized the proffered opportunity of contributing a portion toward that object, as far as my limited knowledge, joined to the experience of others, would permit.

Having now matured my plans, I herewith have the honor to communicate them to you, in as brief a manner as it can be done intelligibly.

1. *The Governor.*—The principal difficulty to overcome lay in the construction of a governor, that would reduce the inequality of rotary movement in the recording cylinder, to the smallest possible amount. While considering different expedients, I became indebted to my friend, Mr. J. E. Hilgard, of the United States Coast Survey, for the idea, that presented to my mind the fewest objections, theoretically as well as practically. It consists in an arrangement, that makes the galvano-magnetic power, as called into existence for a moment at every beat of the second pendulum of an astronomical clock, the regulating agent, in producing by mechanical contrivances, a *permanent* change in the friction governor, that remains even after the arrival at, or return to, the desired rate.

And in this it differs essentially from all governors heretofore employed, from the governor of a steam engine, to that of an equatorial telescope movement, all of which, after correcting the disturbed rate, return to their former position, which, the disturbing cause remaining, soon reproduces the necessity of continued regulation, until finally, it can only attain a medium rate between the power of disturbance and that of the governor.

Whatever may be the circumstances that will affect the rate of the register, whether permanent, such as wear, or temporary and local, such as changes of temperature or intervention of dust, it will imme-

diately (in the course of a second) fully and permanently be compensated for.

The mechanical arrangements for this purpose, consist of a metallic disk of about four inches diameter, having one half of its circumference raised above the other, about one-twentieth of an inch. On this circumference lies the end of a lever, kept in contact with it by the slight pressure of a spring. The other end, beyond the lever's fulcrum, and at a right angle to the first, terminates in a click, catching into a segment of a spur ratchet wheel, whenever the lever runs on the lower half of the disk's circumference; but is lifted out when on the raised half. This lever is attached to a rod that receives a motion from an electro-magnet, sufficient to produce a change of one tooth of the ratchet, either backward or forward, whenever a galvanic circuit is made. Another click, shaped something like an anchor, holds constantly the ratchet in position, except during the instant of a regulating movement. A pin on the direct action click, catches, during the forward movement, a short lever on the anchor click, lifting it from the ratchet, while the opposite end falls into it, preventing it to move more than one tooth at a time. A metallic ring, held against the revolving disk by an angular lever, receives a pressure against it by a spring attached to the radius of the ratchet.

A second spring, whose tension is adjustable by means of a screw with a divided head, is attached to the outer end of the lever. The disk has on the other side a pin fixed near the circumference, which at each revolution, for a moment lifts up a lever, to the end of which is attached a conducting wire from the battery, dipping it into a globule of mercury, through which the circuit is made. This lifting takes place at the moment when the runner slips from the higher to the lower portion of the disk, which is the time of perfect agreement between the register and clock, and the time at which the spark is transmitted from the battery by the clock; but the connecting wire being lifted out, no circuit is made, and no action can take place by the regulating magnet. If, however, it goes too fast, the connection will have been restored, when the spark is transmitted, the runner will be on the lower half, and let the click into the ratchet, which, receiving a momentary push from the electro-magnet, will force the ratchet one tooth forward, and tightening the friction spring, by increased friction retard the run of the register. If, on the contrary, its motion is too slow, the runner will be, at the moment of clock circuit, on the raised half of the disk, the direct action clock lifted off the ratchet, and, by

the force of the magnet, the anchor click made to let go the ratchet one tooth backwards, which, slackening the friction spring, will increase the speed of the register. The main regulation being first made by the other spring, attached to the micrometer head screw, the ratchet spring only serves to equalize small differences, and is in proportion so much weaker, in order not to produce too great a change by a single regulation. If now the length of circumference of the disk $=12$ inches, the connection being broken for "no regulation" while the runner passes over $\frac{1}{10}$ of an inch, the greatest error at which no regulation takes place, will be $\frac{1}{240}$ of a second, either way.

The act of regulation being however easily observable, even that small portion can be brought into account, whenever it is required to note more minute differences of time. If the range of the ratchet should be found to be too small, provision can be made that, at a certain limit of ratchet motion, the other and more powerful spring is made to change its tension.

2. For *the transmission of the galvanic current by the clock,* the wire laid through the lower portion of the clock case, where, below the pendulum, it terminates with a metal cup, containing a globule of mercury. Another cup, placed near it, and at a right angle with the motion of the pendulum, begins the continuation wire to the register. A forked point is so attached to the end of the pendulum, that both ends pass through the two mercury globules at the same time; thus making a momentary circuit every second. The circuit passes through three different coils, arming at the same instant as many electro-magnets, as often as their power is required.

The register wheel-work, consists of three spur wheels and the same number of pinions. The first wheel of seventy cogs, performing one revolution in five minutes, turns with its barrel on a steel shaft, but is forced forward by two C springs, similar to those that keep a clock in motion while it is being wound up. These springs are attached to a spur ratchet wheel of three hundred teeth. Two clicks catch into this wheel; one that keeps it in place while the winding up clock recedes, serving also to give to the springs the necessary tension in the beginning; the other, an anchor click, keeps up this tension, by forcing the wheel forward one tooth every second, through an electro-magnet made by the clock pendulum. "The break" is made by a + to the seventy cogged wheel. Revolving once in five minutes, it has five side pins near its circumference, that, passing, lift a lever that breaks

the connection for the recording electro-magnet, four times during one second, and the fifth time during two seconds.

To make the register break agree with the astronomical clock, a jointed hand or index is attached to the outside of the axis, which can be moved against a stop, at the moment that the clock beats the three hundredth second, when the joint will give way, and the hand move on without obstruction.

The second shaft or axis has a fixed pinion of fourteen cogs, revolves consequently once in one minute. To this shaft the recording cylinder is attached. It has also a wheel with ninety-six cogs, driving the third shaft with a twelve cog pinion, at the rate of one revolution during seven and a half seconds. This again, with a wheel of ninety cogs, gives to a fourth shaft the velocity of a revolution in one second, through a twelve cog pinion. It is on this shaft that the friction governor is applied, as described in the beginning. It has also a metal disk, larger than that of the governor disk, that serves for the axis of a fly wheel about seven and a half inches in diameter, to run upon. This fly wheel axis holds on the disk *by friction only,* as by any other means it is impossible to avoid the shake or elasticity, consequent upon application of cogs or bands for the increase of speed, For, as the fly wheel receives its impulse from the machinery it is intended to regulate, if this impulse from some cause temporarily diminishes, the fly wheel speed will be greater than that of the machinery, which to aid over the abstraction, it first must go back in the looseness of the cogs or the elasticity of belts, before its influence can be felt, and thus large errors in the subdivision of seconds are likely to occur.

The recording pen, in order to leave the other works unencumbered by it, is moved along the cylinder by a separate contrivance, consisting of sliding ways with a screw the whole length between, that on one end has a spur ratchet wheel with sixty teeth, of which one tooth is moved every second by the same electro-magnet, that keeps the works wound up. It will consequently perform one revolution per minute, moving the recording pen in the same time one thread of the screw. To save recording surface, while no observation is in progress both the screw and pen can at any moment be thrown out of action, while the other works move on.

The objects of importance attained by this register are:

1. A governor that immediately and permanently compensates for all disturbances within a very small fraction of a second.

2. The wheelwork is reduced to the smallest practicable number of geared pieces; these being most liable to inequalities of motion, less chance of error from this source is given.

3. Having no driving weight, it becomes much more compact and easily transferable from one place to another.

4. With the exception of the small fork at the end of the pendulum, all fixtures to the astronomical clock are avoided; "the break" being attached to the register.

5. There remains no cause for disturbing the register during the progress of observation in winding it up, as, once set in motion, it will continue as long as its connection with the battery through the pendulum remains unbroken. Very respectfully,

Your most obedient servant,

WM. WURDEMANN.

FIFTH DAY: FRIDAY, MAY 9, 1851.

(Morning Session.)

ASSOCIATION met at $9\frac{1}{2}$ A. M. Prof. BACHE in the chair.

The following recommendations and communications of the Standing Committee, were presented and adopted:

1. That the members of the Association visit the Cincinnati Observatory on Saturday afternoon and evening, and the Orograph of Messrs. Sellers and Whetstone on Saturday morning.

2. That the following gentlemen be a committee to receive the Mss. of the Proceedings of the Cincinnati Meeting from the Permanent Secretary, to contract for the publication of the same, and to carry the volume through the press, subject to the revision of the Permanent Secretary:

Hon. JACOB BURNET, Chairman.

JOHN P. FOOTE, Esq.,	JAS. W. WARD, Esq.,
Prof. O. M. MITCHEL,	J. G. ANTHONY, Esq.,
THOS. RAINEY, Esq.,	R. BUCHANAN, Esq.,

GEO. GRAHAM, Esq.

3. That the Association adjourn this evening at the close of the exercises already appointed.

4. That the following named gentlemen be committees to examine, in conjunction with the Permanent Secretary, all papers submitted for publication, with authority to present abstracts of the communications instead of full papers, and to omit the publication of any paper which they do not approve, returning the same to the author if desired :

Mathematics and Physics.—Profs. PEIRCE, HENRY and BACHE.

Geology, Mineralogy and Chemistry.—Mr. FOSTER, Profs. HALL and DANA.

Zoology and Botany.—Prof. AGASSIZ, Drs. TORREY and LEIDY.

5. That the following gentlemen be appointed to report the discussions of the present day: Profs. HALL and AGASSIZ, Mr. WELLS, Prof. BACHE, Mr. FOSTER, Drs. ENGELMANN and YANDELL.

Prof. BACHE then resigned the Chair to Mr. FOSTER, and the reading of papers commenced.

1. REPORT ON THE VERTEBRATE FOSSILS EXHIBITED TO THE ASSOCIATION. By Prof. L. AGASSIZ.

(*Abstract.*)

THESE fossils are very important and very interesting. The Committee has had so little time, that it can only select a few of the most prominent for notice this morning.

Less attention has been paid to the vertebrata of the West, than the other fossils. The specimens are yet very incomplete, and many of the species not described. I can now merely call the attention of the Association to this deeply interesting subject, and would wish to retain some of the specimens, for future examination and discussion.

No. 1, is a fish procured and presented by Prof. BRAINERD of Cleveland.

The specimen is from a stratum of coarse-grained sandstone, called in the Ohio Reports, the "grindstone grit," which is thirty-eight to

forty feet thick, its lower face about two hundred and twenty feet above Lake Erie, and its superior face one hundred and forty feet below the conglomerate.

It was found at Chagrin Falls, 18 miles southeasterly from Cleveland, and belongs to a subdivision of the genus *Palaeniscus*.

No. 2, is a buckler headed fish, presented by Dr. Norwood, of Madison, Indiana. Its exterior is covered with bony plates, forming a shield resembling the Chelonian reptiles. Its cuirass is of that class. It is deeply interesting, as representing a very ancient period of the fossil fishes, and to be discussed in reference to the origin of the footprints of the lowest sandstones.

This specimen is situated near the surface of the Cliff Limestone of Ohio and Indiana, a few miles from Madison.

There are also other fishes with spines shown to us, from Dr. D. D. Owen, of New Harmony, found at Levenport, Indiana, which resemble the carboniferous fishes near Bristol, in England.

No. 3. This is a jaw of the genus *Myliobates*, belonging to the tertiary presented by Col. Wailes, of Mississippi. Most of the genus have spines. It is a new species, and we can now only recommend it for further study.

No. 4. Procured and presented by D. Christy, Esq., of Oxford, Ohio, from the upper part of the Cliff Limestone of Delaware, Delaware county, Ohio. It is part of the jaw of some undescribed ganoid fish, requiring a close study and examination under a microscope, to determine its character.

No. 5. These are some very interesting mammalia. A jaw with teeth of a large *Rodent*, (*Castoroides ohioensis,*) the same as mentioned in the Ohio Reports by Mr. Foster. It is from the gravel at Nashport, on the Ohio Canal, in Licking county. Similar bones, with the skull, have been found in New York. The whole require elaborate study.

No. 6. Part of the lower jaw of a *Pachyderm*, the species not known, but no doubt allied to the tapir. Presented through Prof. Brainerd by Geo. E. White, Esq., engineer of the Cleveland and Pittsburg railroad company, with many new and interesting shells from the same locality, belonging to the coal. The jaw was taken from an erosion in the coal series, on Yellow Creek, Columbiana county, Ohio, beneath thirty feet of white clay; elevation two hundred and eighty feet above Lake Erie.

No. 7. The skull of the *Bos bombifrons*, from the Arkansas river.

It is described in the first volume of the Transactions of the Philosophical Soctety of Philadelphia, but this specimen is much more perfect than that. Presented by Thomas Kite, of Cincinnati.

The specimens before us show how much is to be done toward completing our knowledge of the fossil mammalia of the West. This skull is important, because it may enable us to trace the relation between the living and the extinct species.

2. REPORT ON THE INVERTEBRATE FOSSILS EXHIBITED TO THE ASSOCIATION. By Prof. JAMES HALL.

[*Not received.*]

Mr. CHRISTY followed the remarks of Prof. Hall, by a word of explanation, stating more fully the views of M. de Verneuil in reference to the Rockford Goniatites. M. V. had remarked in one of his letters, that these Goniatites, in the structure of their septa, present a curious blending of the forms of the Carboniferous and Devonian Goniatites, which makes them exceedingly interesting; hence his anxiety to ascertain their true geological position.

3. ON THE HISTORY AND NOMENCLATURE OF SOME CULTIVATED VEGETABLES. By Dr. T. W. HARRIS, of Cambridge, Mass.

(*Abstract.*)

THE errors that have grown, and spread, and multiplied, with the lapse of time, in this neglected field of research, said Dr. Harris, require to be cleared away. De Candolle remarked that the species of the genus *Cucurbita,* ought to be worked out anew. The names of the pumpkin and squash are no longer used precisely in their original sense.

In general, they are the fruits of the plants belonging to the miscalled genus *Cucurbita,* as now restricted by Meissner and Endlicher. The illustrious Linnæus, following in the steps of his botanical predecessors, for whose errors he is not to be held accountable, gave the names of *Cucurbita pepo* and *Cucurbita melopepo* to those kinds of pumpkins and squashes that had been longest and best known. He added to the list one more old species, the *verrucosa,* and a new one, the *ovifera,* said to have been brought by Lerche from Astrachan. Several more species are now enumerated in scientific works, some separated from the *Pepo* of Linnæus, (*C. maxima* and *C. moschata,*)

and others more recently detached and characterized. Most of the pumpkins and squashes that are cultivated in the United States as articles of food, have been referred to the Linnæan species. Ever since the time of Caspar Bauhin, whose "Pinax" seems to have served as the basis of botanical nomenclature, it has been taken for granted that the pumpkins and squashes were the *pepones* and *melopepones* of the Greeks and Romans. If this be admitted, it must follow that pumpkins and squashes were not only well known to the ancients, but that they were natives of the Eastern continent, to which, indeed, the most common kinds are actually assigned by modern botanists. Dr. Harris, however, shows that the *pepones* and *melopepones* of the Greeks and Romans, were not pumpkins and squashes—that the latter were unknown to the ancients; that they did not begin to be known in Europe until *after the discovery of America;* and that they are natives of America. He traces out, in this paper, a detailed account of the ancient vegetables; proves that the musk-melon which has been long known and cultivated in Greece, is now called by the modern Greeks *peponi,* a word derived from the ancient name of the fruit; that the monuments of Egypt, though containing representations of many other plants, have none that can be referred to the peculiar products of which this paper treats; and that writers on materia medica enumerate four kinds of cold and demulcent seeds, namely, those of the citrul, cucumber, gourd and melon; but make no mention of those of pumpkins and squashes, which are included in the list by modern physicians.

The common nomenclature of the cucurbitaceous plants, in the languages of Europe, has become very much confused, many of the names now embracing species, and even genera, to which they did not originally belong. The European gourd or calabash, originally a native of southern Asia, took its names mostly from the Latin *Cucurbita.* It was known to the Anglo-Saxons, and was by them called *cyrfoet.* Though long cultivated by the Romans, by whom, perhaps, it may have been carried to Britain, it was not generally introduced in western Europe until the time of Charlemagne, who greatly encouraged its cultivation. Tragus, who wrote in the early part of the sixteenth century, gave the first good figure and intelligible description of it. The French call it *courge;* the English, *gourd;* the Germans and Swedes, *kûrbis:* the Dutch, *kauwoerde;* the Spanish, *calabaza,* and the Portuguese *cabaça;* all which names are derived from *Cucurbita.* The old names *abóbora abóbara,* by which it was known in Portugal, and the Danish *græskar,* are of uncertain origin. *Zucche* and *zucca,* the Italian

names for the gourd, are probably derived from the Greek *sikua*. *Citrouelle*, was the old French name for the water-melon, which is equivalent to the English *citrul*, and to the pharmaceutical *citrullus*. All these European names were afterward applied to pumpkins and squashes.

The old botanists by whom these fruits were first described, were chiefly Brunfelsius, Tragus, Fuchsius, Cordus, Matthiolus, Turner, Dodonæus, Lobelius and Dalechamp—all of whom, except Lobelius, died before the year 1600. The name *squash* was obtained by our forefathers from the Indians, together with the fruit to which it belonged. It is worthy of note that John Eliot, the apostle of the Indians, in his translation of the Bible into the language of the Massachusetts Indians, which was first printed in 1663, and was the first Bible printed in America, could find no other words for *cucumbers* and *melons*, occurring in Numbers xi. 5, than *askootasquash* and *monaskootasquash*, hereby indicating that these fruits were unknown to the Indians by name. It seems, however, that the Indians had a name for gourd; for Eliot renders this word *quonooask*, in Jonah, iv. 6, 7, 9, and 10. Several of the French Missionaries in Canada have mentioned the *citrouelle* cultivated by the Indians. A number of extracts from early voyagers, were cited by Dr. Harris in this connection, which prove that the vegetables alluded to were in common use among the aborigines through the whole extent of country from Florida to Canada, and probably far to the west; and hence they could not have been derived from Europeans, even if they were not originally indigenous to the soil.

4. Some Remarks on the Geology of the State of Missouri. By Dr. H. King, of St. Louis.

The entire area of the State of Missouri, since the definite settlement of its boundary line between the States of Arkansas on the south, and Iowa on the north, is about sixty-seven thousand square miles. It is divided into two nearly equal portions, north and south, by the Missouri river, which crosses it in a nearly east and west direction. It was my intention to have confined my remarks to that portion lying south of this river; but the paper submitted at the present meeting from Dr. D. D. Owen, U. S. Geologist, no doubt, otherwise, as correct as it was interesting, containing some inaccuracies, or inconsistencies with the information I have collected as to the outlines of the coal deposits and Carboniferous formation of this portion of the State of Missouri, I shall take occasion, when treating on these subjects, so far

to overstep the limits which I originally proposed in this paper, as may be necessary to give my views on them.

With this exception, I shall confine my remarks to the country south of the Missouri river. What I have to say is almost exclusively the result of my own observations, made from extensive explorations, and in small part, from reliable information which I have been able to collect from others during the explorations. Notwithstanding I have devoted much time to this subject during the last twelve or fourteen years, with the most anxious desire to increase my knowledge, I am still conscious that a great deal remains to be done; that many more years of constant exploration and careful observation, are necessary to work out a correct and complete account of this highly interesting portion of the United States. What I have, therefore, to present to the consideration of the Association, must be considered rather as a sketch, the outlines of which may be assumed to be generally correct, but whose complete filling up will require considerable more time and observation.

The geological formations of this region consist of the Primitive, the Silurian, Carboniferous, and Cretaceous ? together with the more recent alluvial and diluvial deposits, common to the whole of this portion of the Mississippi valley. I shall confine my observations, however, to the three first named; the alluvial and diluvial deposits presenting nothing of peculiar interest, whilst the supposed Cretaceous or Greensand, occupying a somewhat isolated position in the south-eastern portion of the State, has not yet become the subject of my explorations. To make my remarks more intelligible, and of more ready appreciation, I have prepared several sections, crossing the formations in different directions, starting from and terminating at different points; and also several diagrams, to elucidate more clearly local phenomena; but as none of these will accompany this paper in its printed form, I shall endeavor to make my remarks comprehensible, without their assistance.

Instead of describing geographically the outlines of each formation, which would require considerable familiarity with the topographical and political divisions of the State, to understand without constant reference to the map, I shall follow these formations as they present themselves in the large profile or section which I have the pleasure of exhibiting to the Association. This will enable me to give a very correct general idea of the stratigraphical relationship of the formations, whilst by occasional reference to the small diagram which I

have prepared for the purpose, I shall be able to make sufficiently near approximation to the several superficial areas and relative positions. This section is intended to show the geological character of the country from St. Louis, in a direction a little west of south, to the Iron Mountain and Pilot Knob. Extending about eighty miles, it embraces our three great or principal formations—Carboniferous, Silurian, and Primitive. The horizon or level from which we take our departure, is near the upper surface of that limestone on which St. Louis is built, and which some, in their zeal to make every thing American conform to a European type, have described as "Mountain limestone," "Yorkdale limestone," etc., etc. Without passing through it, this limestone has been bored into for more than four hundred feet, for the purpose of making an Artesian well. I estimate its entire thickness to be between five and six hundred feet. It is purely a calcareous rock, occasionally including nodules and irregular sheets, rather than strata, of Silicious matter. The beds of which it is composed are generally thick, often massive, and rarely thin or shaly. Its general dip is toward the center of the the great Illinois coal basin, or nearly north-east; but this dip is at a very small angle. Consequently, rising slowly as we advance over it in the direction of our line, we do not pass its final or lowest outcropping edges, until we have reached the distance of some fifteen or twenty miles from the point of our departure.

Ascending however with greater rapidity than the strata, as must necessarily be done in following this line, the explorer finds himself temporarily above this subdivision of the Carboniferous formation, about five miles south, and here encounters the coal itself, in a deposit averaging about four feet in thickness, and extensively worked for the supply of the city of St. Louis. This coal-bed then lies above this massive limestone deposit, and separated from it by only a few feet of clay, and is covered with limestone, with thin deposits of shale occasionally intervening. It is not correct to call this coal deposit an outlier of the Illinois coal basin, and could only have been so considered, by looking for its line of connection in an easterly direction, instead of a northeasterly one, the true direction of the dip of the basin. These mines are worked in the extreme south end of an angular projection of the Illinois coal basin, occupying apparently a slight depression of this form in the underlying limestone; one side of the angle crossing the Missouri river about twenty miles northwest of St. Louis, the other reaching the Mississippi six or eight miles above that city; the first connecting with a similar deposit on the north side of the Missouri,

the other doubtless having its connection with the coal deposits that rise above the level of the river, in the Illinois bluffs, opposite St. Louis. As these lines are the boundaries or outlines of this coal bed south of the Missouri river, we ought to, and probably shall find coal throughout the area they embrace. As yet, few or no explorations have been made anywhere in it, in search of this material, except at the mines just referred to, and along the bluffs of the Missouri and Mississippi, where it is found outcropping. Whether it can be worked advantageously in competition with the many other mines near St. Louis, must depend in a great measure upon the quantity and quality of the coal, the depth of the bed below the surface, and the facilities or difficulties attending its exploration.

Having thus shown that these coal deposits near St. Louis, on the west side of the Mississippi river, are not mere outliers or small detached basins of the great Illinois coal field, but in fact a continuation thereof, and covering an area probably of one hundred square miles, let us proceed with our remarks. Passing over the extreme southern point of the coal deposit, we again reach in tracing out our original line, the underlying limestone; being the same as that on which we established our starting point, and which for convenience of description or designation, we may call the St. Louis limestone, without stopping to inquire whether it does or does not correspond in some of its features with some foreign deposit of this formation. This limestone is strictly Carboniferous, as is proven by its position, as well as its fossils. If we take into consideration the extent of the great coal basin to which it belongs, and assume it to have a nearly equal area, and a thickness averaging what it has at St. Louis, it must be one of the most enormous deposits of carbonate of lime on the face of the globe.

Below the limestone, we have next in order a silicious sandstone, generally of a brown color, from oxide of iron, with which it is sometimes highly charged. Its thickness is generally from forty to one hundred feet, and it comes to the surface on the Mississippi, a short distance below the mouth of the Maremec River, and on the Missouri, about thirty-five miles west of St. Louis. It is an interesting portion of the formation, as it appears to have some relation to the salines, or salt springs of the State. In the western part of Missouri, on and near the upper portion of the Apage river, where the Carboniferous formation is still more largely developed than in the eastern part, I have always found the salt springs close to this deposit. Whether the

saline materials are embraced within this sandstone, or whether the porosity of the latter makes it a fitting conduit for the saline fluids of the higher plains of the Northwest Territory, and through which it finds an easy passage to the lower level of the States of Missouri, Illinois, etc., I am not prepared to say.

Below the sandstone is the second important coal deposit of Missouri. It appears to consist sometimes of a single bed, and often of two beds; in the latter case with a few feet of clay and shale intervening. It does not appear to have been found as constantly as the superimposed sandstone, and occasionally it seems to thin out to a single bed only a few inches in thickness. The coal of this, as well as of the upper deposit near St. Louis, is bituminous, burns freely, with a long flame, a slight agglutination of particles, and leaving a moderate residuum as ashes.

This deposit is succeeded or underlaid by another limestone, which I estimate at from two hundred to three hundred feet in thickness. I have generally classed it as belonging to the Carboniferous formation, with some hesitation however, as some of its contained organic remains, seem strongly to indicate it as Devonian. But as I have not implicit confidence in the applicability of all geological subdivisions made in a remote country, and on a comparatively limited area, to the condition of things in this country, I am not disposed at once to concede this portion of the formation of Missouri to the "Devonian" merely because it contains a few fossils, sometimes considered as belonging to that formation in Europe, while quite as many, if not more, would be classed as Carboniferous.

Having thus reached the line of demarcation, though a debatable one, between the Carboniferous formation of Misssouri, and the formations that underly it, it will be a proper time to give the general course or directions of this line. For reasons before adverted to, I shall not only give it from my own observation on the south side of the Missouri river, but from the best information I have been able to collect, endeavor also to follow it on the north side of that stream, commencing on the western boundary of the State, at a point near the head waters of Sac river, a tributary of the Osage, thence northeasterly nearly with the course of that tributary to its junction with the Osage river, thence down the Osage to the vicinity of the town of Warsaw, thence with an irregular but generally northeasterly direction to the Missouri river, a few miles west of Jefferson City, the capital of the State, there crossing the river, and continuing the same general

direction to Salt river, in the northeastern part of the State. The information I have collected, leaves it somewhat doubtful whether the line does actually continue on to, or near Salt river, intersecting, or rather joining, the line which we have yet to follow from this point southwardly, or whether it does not become more deflected to the north, and ascend near or quite to the boundary line between Iowa and Missouri. Leaving this, however, to be settled by future investigation, and commencing on Salt river, we continue the line in a generally southerly direction, nearly parallel with the Mississippi river, and probably about thirty miles, as a general average, distant from it, until it reaches the Missouri river, opposite the point to which we have already traced it on the south side of that river.*

All that portion of the State lying on the convex side of the line above described; that is, on the northwest, north and east, following it in the order in which the line was described, is Carboniferous. It is yet, however, to be determined *positively,* whether these are portions of one and the same great coal basin, or whether they are distinct and disconnected, by the somewhat elevated range of land that divides the waters of the Missouri from those of the Mississippi. My own impressions are in favor of the former, though if the latter should prove to be the case, we shall still find that the area of the formation in Missouri, will probably exceed twenty-five thousand square miles.

It would lead to no useful result, to dwell longer on that limestone which I have already referred to, as being the deposit with which, or in which, the Carboniferous formation terminates. I flatter myself with being able at some future time, to investigate it more carefully than I have yet done, and to determine its true character.

Passing below this, we arrive at a portion of the formation that corresponds with, perhaps it would be more correct to say that is a continuation of, the lead bearing rocks of the upper Mississippi, and its underlying blue limestone. For here these two divisions are so intimately connected, that their fossils are apparently indiscriminately mixed throughout the entire division. The distinctive lithological characters existing in the subdivisions of the country on the upper

* There is another small portion of the Illinois coal basin, that crosses the Mississippi river into Missouri, embracing the town of St. Genevieve, and a semilunar tract below it, but which is of comparatively little importance, except for the evidence it gives of the constant recurrence of the salt springs, in this, the lowest portion of the formation. Here the sandstones and lower limestones occur, but coal has not yet, I believe, been found.

Mississippi river, are also lost in Missouri, the whole being blended into one grayish or ash-colored limestone, averaging probably about one hundred and fifty feet in thickness. Some small veins of lead ore occasionally make their appearance in this division of the Missouri metalliferous rocks, but no where has it yet been found in quantities sufficient to justify exploration.

With this division, we enter upon what is considered, and commonly received in this country as the Silurian formation. In adopting this name, we wish it to be understood that we do so, as we presume every other American geologist does, as a temporary expedient, to enable us to compare our observations with those made by others under similar circumstances, and not as a fixed system in our nomenclature. The investigation of American geologists has already shown that the United States has the entire Palæozoic series developed on such a scale, that instead of borrowing terms significant of its subdivisions from foreign countries, it has a right to aspire to the honor of offering a regular series of types to them. The naming of these types is a subject that is very properly yet held in abeyance, and it will doubtless be one of the duties of the "American Association for the Advancement of Science," to settle the question for this country, at least, if not for the scientific world.

Following in a descending order the rock or deposit which we have just referred to, as embracing "the Lead-bearing," "Magnesian limestone," "Cliff limestone," (for these several names have been all used to designate it,) and the Blue limestone which underlies it on the upper Mississippi river, we have a sandstone exactly corresponding, in lithological character, to the sandstone underlying the Blue limestone of that region. Like that, it contains no fossils, and therefore we are obliged to rely, in determining its position, upon the next two most important evidences—its stratigraphical and lithological characters—these exactly agreeing with the same deposit on the upper Mississippi, we have no other alternative than to accept it as the same.

The investigations of Prof. Hall, the able palæontologist of the New York Geological Survey, having determined the position of "the Cliff and Blue limestones," just now described, the latter of which, at least, he says, is the equivalent of the Trenton limestone, we have a horizon for our starting point, over which the Survey has shed such a flood of light, that we trust to find our way in the twilight it spreads over our Missourian researches. But we shall attempt little else, at this time, than to lay the results of our own explorations before the Association.

The observations of a single individual, under far more favorable circumstances than it has been our good fortune to enjoy, over so extended and varied an area, would necessarily be very imperfect: to draw hasty and bold conclusions from them, would require a spirit which he who has the honor of addressing you, trusts is not one of his attributes.

If we correctly appreciate the determinations of Prof. Hall and other eastern geologists who have extended their researches into the Mississippi valley, the sandstone now under consideration is by them supposed to be the equivalent, at least, of the Calciferous sand rock of the New York Survey. If this could be determined definitely, on palæontological evidence, or even problematically, by strong lithological resemblances, its stratigraphical relations might be accepted as sustaining the idea. But as we are not aware that any assistance is derived from either of the two former, the argument derived from the latter must be based upon an assumption that is itself to be proven, and which we may hereafter have occasion to show is doubtful, in a high degree. It may prove to be the Calciferous sand rock of New York, or its equivalent; but it does not necessarily follow that it should be so because there is no other member of the Palæozoic series of that State to which it can be referred. We know of no great geological law that requires such an absolute subserviency to only one system of any country so varied and extensive as ours. It is quite within the range of probability that this sandstone does not exist in the New York series; and it is even possible that there may be other great centers of formations in the United States, besides New York, or even the Alleghany mountains, from which not only the sandstone, but perhaps some of those subdivisions which the New York system appears so ready to absorb, may more properly be derived.

This sandstone is remarkable for its pure silicious character. Occasionally it is colored slightly by iron, but generally very white, and apparently free from all foreign admixture. Sometimes hard enough for building purposes, it is more generally soft or friable, and easily reduced to the condition of sand. It is exported in considerable quantities for the manufacture of the finest quality of glass. It frequently makes its appearance in the top of the hills between St. Genevieve and the Maremec River, presenting a bold, wall-like escapement or bluff. In these cases it has received the common name of *Rock Fort,* in the county. Its thickness, I am disposed to believe, varies considerably,

but may be assumed generally at about one hundred and fifty or two hundred and fifty feet.

Next in order below this sandstone, we find a second deposit of Magnesian limestone, much resembling the one above the sandstone just referred to; and also like, in many respects, the same species of limestone that makes its appearance on the Mississippi river, at and near the mouth of the Wisconsin river. It is generally of a light yellow or buff-color, sometimes intermixed with strata of a reddish brown or green. It is not often massive, but generally in thin beds; and when it crops out, often gives origin to numerous barren belts or spots, around which the forest, rising in all its primæval luxuriance, presents a peculiar semi-cultivated aspect to this region. It appears sometimes to have interposed deposits of sandstone, whose continuity I have not been able to determine. So far as my investigations have gone, it appears to be destitute of fossils. I have not been able to make a satisfactory approximation of its thickness, but am satisfied it is much greater than the last described magnesian limestone; provisionally, it may be assumed at five hundred feet. It appears, also, to be destitute of lead ore in workable quantities, but often contains iron ore in promising abundance and quality. We cannot stop to inquire to what particular subdivision of any of the systems of this country or Europe it can be assigned; the same difficulty would attend this, as the sandstone we have just discussed. To give it a general location, to enable the inquirer to carry it more readily in his mind, it is sufficient to say that it lies below the Trenton limestone of the New York Survey, and amongst the lowest of the Silurian system.

The next member of the series that presents itself in the descending order, is a *sandstone*, so exactly resembling the one last described, in its lithological character, that it is impossible to designate any distinguishing difference, except that its lower portion passes, when fully developed, into a cherty mass, sometimes porous, often compact, and covering the tops and sides of the hills and ridges with its comminuted remains. This sandstone is generally not quite so largely developed as the preceding one, and may be estimated at about one hundred and fifty feet in thickness. In the sandstone, properly speaking, I have never found any fossil remains; but in its lower cherty portion, they frequently occur. Several species of *Lituites, Euomphalus, Pleurotomaria, Natica*? are the forms that most frequently present themselves, but I have not been able to identify any of them with those of similar

genus of other countries. If we assimilate the sandstone last described with the Calcareous sand rock of New York, surely there is none other left in that system to which we can assign this one, than the Potsdam sandstone. But, to do this, we must disregard its palæontological character, and rely only on its stratigraphical relations. But is this necessary? Shall we, merely to maintain the order of a system that is undoubtedly very regularly made out for the region to which it belongs, disregard this, the most important of our geological means, in determining sequences, and place our confidence in one far less reliable? Such a course would be a devotion to *system* more allied to a species of bigotry, than is consistent with rigid scientific investigation. This may be an independent formation, not represented in New York or elsewhere, and yet so nearly contemporary with the first evidences of organic existence there, as to be associated with them in the same geological epoch. To deny this, would be to assert that all primordial existences were of one character, and must have been created and nurtured under exactly similar circumstances. This we know is not the case; for the difference in lithological character, of the earliest palæontological periods are as great as we suppose the organic contents may have been. Besides, this doctrine of unity of character would also lead to that of *one great center of creation*, which the imagination can more readily conceive, than we can, by our reasoning faculties, prove. If we assume such a center, where shall it be placed? In Russia, in Great Britain, the country of the ancient Silures, New York, or where else? And having located it, how are we to send off the colonies of organic beings, whose remains are offering themselves to our investigation, with the thousands of others, necessarily linked with them in the chain of mutual dependence, but whose organization we may suppose was of such a kind, as to leave "not a wreck behind." Is it not more reasonable to suppose that there were primary seats of organic life—centers of organic creation, around which were clustered beings adapted to the varied circumstances of each locality? Such a theory would be far more consonant with existing laws of nature; and it is far more safe to base our reasonings upon them, than to fly to others whose character depends upon the fertility of our imagination only. There may have been so near an approach to uniformity of circumstances in some of our geological epochs, in all countries—for instance, in the Carboniferous—that a like uniformity might be expected in the remains of the Flora and Fauna of these periods. But because

this has occurred once or twice, or more frequently, it does not follow that it must always have been the case.

There is nothing, to our minds, inconsistent with the principles of geological science, in admitting a great variety of forms amongst the earliest created beings. In fact, such a variety there must have been, for mutual support and permanent existence, or we must invoke some other than the ordinary laws of nature, to account for their continuation and propagation. And then, as now, every thing was adapted to the circumstances and the place to which Creative Power had assigned it. Fishes did not fly in the air, nor birds dwell in the depths of the sea. If the inanimate matter of one of these localities was inimical to the existence of one of the primitive forms of organic beings, that form would not have been placed there, but elsewhere. Why, then, may it not be, that different forms, under different circumstances, shall indicate like or contemporary periods? Do the earliest forms of organic life in the Potsdam sandstone, or the oldest of the Silurian rocks of Europe, occur in a purely silicious rock, that often assumes the appearance of semi-opal, chalcedony, or jasper, as is the case in Missouri? —a material that indicates not only a striking peculiarity in the saline contents of the ocean in which these beings existed, but a strong probability that it was accompanied by an elevated temperature of the waters. Such a condition of things might not have been incompatible with the existence of such forms as we find in the earliest fossiliferous beds of Missouri, but may have been entirely so with such as are found to characterize the, probably, same geological period in other places.

Before leaving the sandstone, it may be remarked, that in some particular localities, it undergoes a change, or passes into an almost pure feslpathic rock, whose decomposition gives rise to large deposits of kaolin. This alteration appears to have some local cause—at least, I have found it, as yet, most frequent in the vicinity of the primitive rocks, whose constituents, we shall see, always embrace a large portion of felspar.

Following this sandstone and chert, we have another Magnesian limestone, the last and lowest of the sedimentary rocks of Missouri. I use the term sedimentary because, although no distinct fossil remains have ever yet been detected in it, I have found some obscure markings which leave it uncertain whether it should be considered as Azoic or Palæozoic. In an economical point of view, it is far the most import-

ant of the Missouri rocks. In it are found our lead, copper, cobalt, nickel, and a large portion of our iron deposits. Fortunately, its area is commensurate with its value. It covers from fifteen thousand to twenty thousand square miles, every where giving indications of its hidden treasures, some few of which are made to add to the productions of the State.

The thickness of this limestone is not known. It has been penetrated by valleys and mines to the depth of three hundred and fifty or four hundred feet, with no indication of its termination. Near the top, it is sometimes thinly stratified, approaching almost to a schistose character; but below it becomes massive in its structure, very hard, generally, but weathering rapidly into irregular forms when exposed.

As I have had cause to give much attention to the mineral productions of this rock, it has given me many favorable opportunities to investigate the conditions under which these productions occur in it. But to do any thing like justice to this interesting subject, would require much more time than I could feel myself at liberty to consume on this occasion. From the little disturbance to which our formations generally have been subjected, and the great facility with which the mineral bodies in this division are followed, many of the difficulties which attend such investigations in other countries, do not exist here. Hence, we may hope that when mining operations are more extensively and systematically conducted in Missouri than they have yet been, many obscure points that now exist as to the origin of mineral veins, and their relation to the included rocks, will be satisfactorily cleared up.

I cannot, however, dismiss this part of my subject without referring to the coal deposits sometimes found in it, particularly in the vicinity of the Osage river. When I first met with this mineral in this position, having, as I supposed, made out the true geological position of the containing rock, it gave me considerable difficulty and embarrassment. Subsequent investigation has fully satisfied me that this Carbonaceous deposit is of a posterior date to this deposition of the limestone, and in all probability cotemporaneous with the lower coal beds of the Carboniferous formation of the State. A section of one of these deposits, occupying the cavity of a lode in the Magnesian limestone, I exhibit to the Association, to give more distinctly the manner of its occurrence. From the cheeks or sides of the lode, I collected some thin plates of copper ore, (pyrites), and it is quite probable that this was originally a lode of this metal, the latter removed by some cause, probably atmospherical, and its place filled by the Carbonaceous mine-

ral. In other places, I found it occupying the heads or terminations of small valleys and ravines; in one of which, mining for lead ore was being successfully prosecuted on the slopes of the valley, a few feet above the coal. In another instance, a few hundred feet from one of these deposits, a well had been sunk about eighty feet deep, and consequently far below the level of the coal bed. But the coal made its appearance in the well. Though not appearing to exist in large quantities, generally, in any one place, these coal deposits sometimes justify regular mining; and in one instance, a shaft more than thirty feet in depth, has been sunk through it without reaching its termination downward. I have never found the coal accompanied by any other rock formation than the adjacent walls, nor with vegetable or other fossil remains. For its character, I refer to the Report on American Coal, made to the Navy Department of the United States, by Prof. W. R. Johnson, where it is described as "Osage river coal."

The primitive formation of Missouri is first met with on our line near a point about seventy miles south of St. Louis, and thirty west of the Mississippi. It consists chiefly of granite, syenite and porphyry; and is what its name indicates, truly the primitive rock, or oldest solid matter of the State. It rises sometimes in cone-like elevations, at other times as detached ridges, to the hight, often, of a thousand or twelve hundred feet above the level of the Mississippi river. Its sides and valleys are frequently covered with the sandstone and limestone heretofore described, and in such quiet relationship as to show that their deposition has taken place since the primitive rocks had assumed the form they now have. We have collected a great many facts, which show beyond the possibility of a doubt that this is the case. It is not at all unusual to find portions or fragments of the older rocks imbedded in those that are stratified. This occurs not only in the lowest Magnesian limestone, but in the overlying sandstone, the lower or cherty portion of which, we have shown, is abundantly supplied with fossils. An interesting example of this is seen on a small creek near the celebrated mine La Motte. Here the sandstone, in regular horizontal strata, is seen abutting against a ridge-like elevation of red granite, and embracing, in the midst of the regularly stratified mass, large and small fragments of this granite. It appears, also, that these primitive rocks, or at least the granite, had been subject to serious disturbance before the deposition of the superincumbent rocks; for we often find it broken through by greenstone trap dykes on a large scale, without any disturbance of the more recent formations. A beautiful and interesting

example of this exhibits itself only a few hundred yards from the place just referred to as an example of the inclusion of granite in sandstone. On the same small creek that presents us that natural section, we find a small cave excavated in the sandstone, whose overhanging and side walls are of this sandstone, in their regular, quiet, horizontal position, whilst the floor is of the red granite, but rent through and broken by two large, distinct, but irregular veins of trap. The contrast between the greenstone and red granite, gives a distinct outline to these veins, and shows the included masses of granite, reft entirely from the adjacent rock, in an interesting position for examination and study. Running the eye along these lines of fracture to the point of junction of the greenstone, granite, and sandstone, in the posterior part of the cave, we see that the two forms terminate on the same horizontal level, and that on them indifferently the sandstone lies in its quiet, unbroken, stratified condition.

Instead of finding these primitive rocks always rising in elevated ridges above the more recent formations of the country, it sometimes happens, from the effects of the denuding agencies that have been at work since the deposition of the latter, that we pass without a perceptible change of level, from a ridge of granite or porphyry to one of cherty, or feldspathic rock, both performing the same office of a water shed to the adjacent valleys. Again, even in the valleys and plains, we often pass at a single step from a floor of porphyry to one of limestone or sandstone, the two lying distinct beneath us in juxtaposition, without the slightest evidence of the former having been disturbed by want of quietude, or altered by increase of temperature on the part of the latter, since they assumed their present contiguity.

Innumerable examples of a like character could be referred to, as showing, beyond a doubt, that these primitive mountains and ridges existed before the deposition of the first sedimentary rocks of the State, although these latter have an antiquity as great as probably any other of the Palæozoic series, in this or any other country. These examples show, indeed, not only that these primitive formations existed anterior to the earliest sedimentary deposit, but that they were subject to great and serious disturbance before the deposition of the latter.

This being the case, have we not here in Missouri another one of those nuclei, or great centers for the origin of organic and inorganic forms of subsequent geological periods? and it is this point which I would particularly insist upon always being kept in view, in studying the extinct fauna of this region, particularly of the earlier Palæozoic

period. We do not know, and never can know, all the differences tending to affect animal and vegetable existence—for doubtless the latter, as well as the former, may have occurred in these remote periods. That all primitive—really primitive—rocks, as they generally exhibit a strong similarity, should be followed by others that also bear to each other a strong similitude, in their organic and inorganic forms, is what we should readily expect and admit. But as these primitive nuclei are not identical, or exactly the same in all their characters, every where, but on the contrary, sometimes differ very greatly, if we suppose them to have contributed, as we know they did very largely, to the inorganic materials of the formations next succeeding, we must expect these latter to exhibit a corresponding difference in their characters. This, then, is one element that would have tended to affect vital existence at the earliest Palæozoic period, and stamp beings coeval in existence with a diversity of form. To this may be added a possible difference in the temperature of the adjacent ocean or sea, its saline contents, the gaseous evolution passing through it from a yet scarcely chemically quiescent globe, and a host of other agencies, all differing more or less at each one of the local centers of existence, and all known and appreciated by that Power which was to plant each being in that spot which his omniscience told him was adapted to its existence, its wants, and its future development.

Why, then, should we expect forms that remain of the earliest fauna of Russia, of England, or even New York, to be exactly the same as those we have or may expect to find in Missouri? If we differ from them in lithological characters and stratigraphical relationship, is it not reasonable to suppose that we shall differ also in our palæontological remains? But though such differences may, and probably will, be found, we have no idea that it will affect the great principles of geology; on the contrary, by adding new facts, it will only tend to lay more broadly and solidly the foundation of this, the greatest and most useful of all the modern sciences.

My friend, Dr. Engelmann, has given me some interesting information in relation to the primitive region of the adjacent State of Arkansas, which he explored some years ago. It is extremely probable that we shall find here another center of inorganic and organic forms, that may give us new subjects for study and assimilation with those of other regions. Texas, too, seems to promise us another point in the chain of subterrestrial mountains, whose now solidified ocean entombs the differing forms that once enlivened the same period.

In the midst of this primitive formation we find the largest and most valuable deposits. The relationship which they bear to each other is not yet satisfactorily made out. The Iron Mountain, which is an irregular ridge, rising about two hundred feet above the level of the adjacent valleys, and covering an area of about five hundred acres of land, is entirely specular oxide of iron, of the purest quality, at least on the surface, and extending from the top of the mountain to within a few feet of the level of the valley. In the excavations made on the south-west face of this hill, or mountain, for the furnaces since erected here, stratified beds of a silicious rock were exposed, dipping slightly toward the valley. This rock contained felspathic crystals, and may have been a modified granite, as that rock makes its appearance in contact with the iron ore on another side of the mountain. But it may also be a metamorphosed sandstone, as this rock is found in some of the valleys, not very distant. About on a level with the tops of the furnaces, or say fifty feet above the level of the base of the mountain, the mining has been pushed into the hill side broadly, and for some distance, exposing a deposit of iron ore in the form of pebbles, or broken masses, of various sizes, up to that of a foot in diameter, closely impacted together, and the interstices filled with a reddish brown clay. This bed, in its thickest point yet opened, is probably twenty feet, evidently increasing toward the mass of the mountain. On the top of the mountain, the iron ore lies in large masses, with surfaces several square yards in area. But within, the solid mass of the mountain is a mystery; whether it is a dyke or vein of ore, projected up through the solid granite and sandstone previously existing, or whether it be a cotemporaneous deposit with one (and which one) of these, are questions to be solved.

The Pilot Knob, another of our large Iron Mountains, lies about five miles south of the one just described. Mineralogically it is of the same character, but differs somewhat in the physical aspect of its ore. But unlike the Iron Mountain, it appears to be associated with porphyry, and passes often by insensible gradations into that rock. The Pilot Knob covers about the same area as the Iron Mountain, has its base at about the same level, but rises probably two hundred feet higher. Its summit is covered with immense masses of solid ore, whose rugged summits overtopping those of almost all the adjacent hills and ridges, became to the hunters and earlier explorers of this country, a noted land mark, in directing them through this then little known region. The name which it thence obtained it still retains, and

the mind can scarcely realize the time, when the wants or the cupidity of man, will be able to level these peaks to a condition in which they will no longer enjoy this distinctive appellation.

These two immense masses of iron ore seem to have become so familiar to the public, that a vague impression appears to be gaining ground, that they constitute all or nearly all of this mineral, of any value, in the State. This is far from being the fact. We have referred to the deposits of it in the oldest Magnesian Limestone, in which it is found generally as hydrated peroxide, almost everywhere. Innumerable other deposits of the specular oxide, some but little inferior in apparent extent to the Iron Mountain and Pilot Knob, are met with throughout the primitive formations, and when the spirit of improvement shall have made them accessible, they will cause this portion of Missouri to become one of the greatest iron-producing districts in the world.

The formations of Missouri appear to have suffered but slight disturbance since their deposition. But, for the facility with which most of them seem to yield to atmospheric and aqueous agencies, by which deep valleys and high bluffs have been formed, much difficulty would attend these geological investigations. The strata lie one upon another with quiet regularity, and no break or uplift marks the period of the commencement or end of any of the divisions. It is only in a few places that we find them sufficiently inclined to forbid the supposition of their deposition at this angle. But when we take a general view of the country, we see beyond a doubt that some dynamic cause has thrown it into undulations, and that these undulations have operated alike upon all the formations, and that consequently it must have been posterior to the most recent or Carboniferous period.* The direction of the uplifted mass appears to be nearly north and south; and it is a striking coincidence that most of the *regular* veins or mineral lodes have about the same direction, rarely differing from it more than ten or fifteen degrees. The greatest amount of this disturbance appears to have been between the Mississippi river and the primitive mountains, and probably included the latter in its action. Although the undulations or wave-like appearance of the ridges, seem to be generally north and south, we are not sure that the direction of the force was not at a right angle, or nearly so, to them: that is, east or west. But

*In these general remarks, I do not embrace the Greensand or Cretaceous formation of the southern part of the State, nor the alluvial or diluvial deposits; nor, of course, the comparatively recent disturbances to which the former have been subject.

this is a subject which requires for itself a considerable discussion, and perhaps a more careful and extended examination of the country; we shall not, therefore, trespass upon the attention that has alrady been so kindly extended to us, by proceeding further in it.

Dr. Engelmann said that the occurrence of crystalline rocks in Missouri, which had just been described by Dr. King, finds a striking analogy in Arkansas, and probably, also, further to the southwest.

Having had an opportunity, fourteen years ago, to spend several months in Arkansas, my attention was drawn to the geological structure of the region between Little Rock and Hot Springs.

The city of Little Rock is built on soft, talcose clay slates. The rock at the lower end of the town, which gives it its name, is of similar, but hard, and highly silicious. Thence this formation extends west and south; in some localities talcose, in others silicious, and in others again, somewhat crystalline, and resembling hornblende slates—almost always tilted up, and sometimes almost perpendicular. Only in a certain part of the country, near Saline river, have I seen the strata nearly horizontal, and apparently dipping from this center in every direction.

Interstratified with this slate is a dark blue limestone, sometimes highly crystalline, and forming a most beautiful black marble. This limestone is of importance, as it furnishes the only good lime the inhabitants can get in this neighborhood, the Cretaceous rocks which I shall mention hereafter, not being fit to burn.

On this formation, and most probably not conformable in stratification, rests a sandstone which is most probably analogous to that of Lake Superior. It is found west of Little Rock, on the river, forming the "Big Rock," on the northern bank of the river, and the "Mammelles," near the southern bank. Whether the sandstone rock of the "Dardanelles" belongs to the same formation, I am unable to say. From the river this sandstone formation extends south-eastwardly, and is crossed by the road that leads from Little Rock to the Hot Springs. These springs, of about 150° temperature, and furnishing pure limestone water, are situated in a narrow valley, formed by these same rocks.

In neither of these rocks have I found a trace of fossils.

Within this district of unfossiliferous sedimentary rocks, I found a beautiful gray syenite, sometimes changed into large masses of kaolin; and at another locality, "Magnet Cove," a succession of hills or knobs

of black and white syenite, mostly coarse grained, and of true trachyte, with large crystals of glassy felspar. At other places anomalous rocks, of singular structure, were observed, having sometimes the appearance of amygdaloid, probably metamorphic. Porphyry and granite, (without mica), which occur with the syenite in Missouri, I have not seen in Arkansas.

The connection of these rocks with the stratified rocks, has not been observed.

In the clay slate, and probably in it only, trap dykes are very common, especially near the Saline river. Sometimes, these dykes, one or more together, traverse the strata of slate, leaving them undisturbed on the edges, or in other localities, bending them upward on both sides of the dyke. In other cases, one or more, (I have seen as many as four) strata of trap are wedged in between the strata of slate, apparently interstratified with them, but evidently forced in after the formation of the slate. In one locality, I have found the ends of these strata running out rounded, as if they had been forced in in a semi-fluid consistency; and not changing the lithological character of the clay slate. In another, a mass of several feet thick had split in hundreds of small veins, only a few lines wide, but easily distinguishable from the *altered* and *stratified* rock.

These trap rocks are very remarkable on account of the presence of black mica, which in some of them occurs in great abundance, and in large and finely formed crystals.

The vast masses of the micaceous or submagnotic oxide of iron found in the analogous formation on Lake Superior, and especially in Missouri, find their representatives in the well-known "Arkansas magnets," the magnetic iron ore of the "Magnet Cove," mentioned above.

Copper, I believe, has not yet been found in this formation; but lead has lately been brought from this region, said to contain much silver. I have seen only small particles of galena in the thin strata of limestone accompanying the clay slate. May not the lead which, according to Dr. King's observations, appears to occur in Missouri, in a formation below that of the lead-bearing rocks of Wisconsin and Iowa, occur here in a still lower Azoic stratum.

The granite and Silurian limestone discovered on the Liano river, a southern branch of the Colorado, in western Texas, appears to be connected with the granitic and syenitic centers in Arkansas, Missouri,

and on Lake Superior; and perhaps the Silurian rocks still further to the south-west, about Chihuahua, up to the plateau of Mexico, also belong to this great chain.

While in Missouri, the lead-bearing Silurian rocks, and in Texas the Cretaceous strata, surround these Azoic formations, in Arkansas a largely developed Carboniferous formation, in which the sandstones are very prevalent, and the limestones almost entirely wanting, joins them on the north and west, and Cretaceous deposits on the east and south; they are found leaning against the silicious slate of the "Little Rock," at the city of that name, and are likewise met with south of the Washita river; and from these uninterruptedly to the Red river.

5. A Comparison of two different Methods of Calculating Mean Temperature, and on the Mean Temperature of Cincinnati; being the Results of Observations made at Woodward College, Cin. By Joseph Ray, M. D., Professor of Mathematics and Natural Philosophy.

In meteorological observations, one of the most important elements is the mean temperature of the day, as from it, the mean temperature of all the longer periods is derived. Those familiar with works on meteorology, and with the practice of observers, are aware that no uniform method of determining mean temperature has yet been agreed upon. The most common method consists in taking the mean of the minimum and maximum temperatures. Another consists in dividing the day, a period of 24 hours, into minor divisions—finding the mean temperature of each, and then the mean of the whole. The most convenient subdivision of the day of 24 hours, is into periods of about eight hours each, as this requires but three observations, say at the minimum and maximum periods, and at a point equally distant between the maximum of one day and the minimum of the day next following.

The first method has the advantage of simplicity; thus, if a is the minimum temperature, which generally occurs at or near sunrise, and b the maximum, which generally occurs at or a little after 2, P. M., then the mean temperature is expressed by $\frac{1}{2}(a+b)$.

If to these two observations, we have c and d, the temperature at

10, P. M. and at sunrise the following morning, then the mean temperature of each eight hours will be

$$\frac{a+b}{2}, \quad \frac{b+c}{2} \quad \text{and} \quad \frac{c+d}{2};$$

and the mean of the whole will be

$$\tfrac{1}{3}\left(\frac{a+b}{2}+\frac{b+c}{2}+\frac{c+d}{2}\right)=\tfrac{1}{6}\,(a+2b+2c+d)$$

which, expressed in common language, requires that to the morning observation, we should add twice the afternoon observation, twice the evening observation, and the next morning's observation, and divide the sum by six, and the quotient will be the mean temperature of the day, reckoning from sunrise to sunrise.

There is a discrepancy between the statements of writers in regard to the accuracy of the common rule of taking the mean of the minimum and maximum temperatures. Some regard it as defective; others, as approaching so very near the truth, as to make it sufficiently accurate. I was, however, convinced many years ago that it was not accurate, and for the last ten years have reduced my observations by the rule just presented, which is sometimes known as De Witt's rule.

About two years ago, finding, after making due allowance for differences of elevation, latitude, etc., that my observations gave a mean temperature of the months and years somewhat less than that of other observers: particularly of my friend Mr. John Lea, of Cincinnati, and of Dr. Engelmann, of St. Louis, I was led to institute a comparison between the results of the two methods of observation here referred to.

As the science of meteorology in this country, is yet in its infancy, and as the comparison of different methods may lead to the adoption of some uniform method, and one calculated to produce results more nearly accurate than those hitherto obtained, I have felt justified in calling the attention of the Association to the subject.

It is obvious that a comparison of results, to be of much value, should extend through a considerable period of time. My observations with reference to this point, embrace a period of about three years. I will, however, present only those for the first four months of the present year, and for the year 1849.

By way of illustration, I will give the temperature of the first two days of the present session of the Association. I select these because the rise and fall of the mercury, between the hours of observation, was nearly uniform, and the days marked by no unusual changes.

	Sunrise.	2, P. M.	10, P. M.
May 5	35°	63°	46°
" 6	36	68	46
" 7	38		

By the common rule, the mean temperature of May 5th, is 49°. Supposing the change of temperature between the hours of observation to have been gradual, as it evidently was very nearly, the mean temperature of the first eight hours of May 5th was 49°, of the second eight hours, $54\frac{1}{2}$° and of the third eight hours, 41°. This gives $48\frac{1}{6}$° for the true mean temperature of May 5th, being $\frac{5}{6}$ of a degree less than that obtained by the common rule. In a similar manner, the mean temperature of May 6th, found by the common rule is 52°, while the true mean, or mean of the means for the periods of eight hours, is $50\frac{1}{3}$°, a difference of $1\frac{2}{3}$°.

It is not to be inferred, however, that in all cases, the mean temperature obtained by the common rule, will be greater than the true mean temperature. Thus, it easy to see, that in those cases where the temperature falls very little during the night, the common rule may give a temperature below the truth. Such cases, however, occur rarely.

I now present a table of the mean temperature of the first four months of the year 1851, found according to both rules. The first column gives the mean temperature of the month by the common rule; the second, by what I term the true or De Witt's rule; and the third, their difference:

1851.	MEAN TEMP.	MEAN TEMP.	DIFF.
Jan.	87°.35	36°.06	1°.29
Feb.	43 .41	42 .44	0 .97
March	47 .29	46 .42	0 .86
April	53 .50	52 .00	1 .50

It will be observed that the differences all lie in the same direction, and that their mean is 1°.16.

The following is a similar table for the several months of the year 1849:

1849.	MEAN TEMP.	MEAN TEMP.	DIFF.
Jan.	32°.75	32°.3	0°.45
Feb.	33 .22	32 .16	1 .06
March	47 .73	46 .48	1 .25
April	53 .80	52 .64	1 .16

1849.	MEAN TEMP.	MEAN TEMP.	DIFF.
May	65 .35	63 .91	1 .44
June	75 .65	73 .90	1 .75
July	73 .85	73 .66	0 .19
August	74 .65	73 .54	1 .11
Sept.	66 .56	65 .33	1 .23
Oct.	54 .57	53 .30	1 .27
Nov.	51 .02	49 .94	1 .08
Dec.	32 .91	31 .60	1 .31
Year	55 .17	54 .06	1 .11

We observe in all the examples that have been presented, that the differences of temperature lie in the same direction, and that their average is a little more than one degree.

A comparison of the observations for the year 1850, would give similar results.

The inference, then, is that the common method of calculating mean temperature, gives a result too great, so far as Cincinnati is concerned; and I feel assured that similar observations in other places would lead to similar conclusions.

In regard to the mean temperature of Cincinnati, I shall state briefly, that the observations were made at the Woodward College, about one mile north of the river, and at an elevation of 150 feet above low water mark in the Ohio. The temperature of the central and less elevated portions of the city, is doubtless higher than that of the college.

The observations extend through a period of sixteen years, but I omit the first six, as the observations were reduced by the old method. By taking the mean of the last ten years, that is from 1841 to 1850 inclusive, I find the result is 53.976 degrees.

If the year 1843 is excepted, which was in some respects extraordinary in regard to temperature, and of which the mean was only 51°.1, the mean temperature of no year differed more than 1.4 degrees from the mean of the whole, and in general the difference was only about half a degree.

But, to find the mean temperature of a place, is like ascertaining the sum of an infinite series of great convergency, but of which the law is unknown. The sum of a few terms gives an approximate result, but the true value can be ascertained only from considering an unlimited number of terms. The true mean temperature of Cincinnati, however, differs so little from 54° as to be unworthy of notice.

Dr. Engelmann stated, that his method of computing mean temperatures had not been from the highest and lowest of the 24 hours, but from the temperature of sunrise and 3 P. M. His meteorological tables of St. Louis, published in Professor Drake's great work, are based on these calculations.

It will be seen at once that the results will be lower than those derived from the highest and lowest temperatures of the day.

If it be argued that the mean temperature of St. Louis can not be higher than that of Cincinnati, as the comparative tables appear to indicate, he would adduce a fact corroborating the above results which only yesterday came to his knowledge.

In Dr. Warder's Horticultural Review, I find the dates of the blossoming of the peach tree since 1814. His own observations permit him to compare the time of their blossoming in ten years. In every one of these ten years they have been from one to six days earlier in St. Louis, and the average date for Cincinnati in those ten years is the 13th, and for St. Louis, the 8th of April.

Prof. Bache remarked that the mathematical problem involved was the determination of the center of gravity of a plane surface, bound by the course of daily movement of temperature, and had been frequently solved, the results agreeing with those stated by Dr. Ray.

In reply to a question from Capt. Wilkes, Dr. Ray stated that he did not intend to recommend observations only in the day time.

6. On some Points of the Structure and Reproduction of Physaolia. By Prof. L. Agassiz.

[*Not Received.*]

7. On the Association of Certain Minerals in Northern New York. By Franklin B. Hough, A. M., M. D., of Sumerville, St. Lawrence Co., N. Y.

Specular Iron Ore occurs in the northern part of New York under two separate forms, entirely distinct, both in geological and mineral association.

The first or crystalline variety is found generally in veins and masses in gneiss, or white limestone—is of a black or steel gray color externally, and when broken, it presents a highly crystalline structure.

Its surface is often studded with crystals of the same mineral, and cavities are uniformly lined with brilliant or iridescent fascets of hexagonal tables.

A constant associate of this variety is crystallized quartz, which usually occurs as a very short prism with terminations at both extremities. The groups of these that are occasionally found, form the most desirable specimens for cabinets. So constant is this association, that after a long acquaintance with localities of these minerals, I have a confident expectation of finding one of these if the other has been observed.

This variety of specular ore has never been wrought with profit in this section of the state. When smelted alone, it affords a hard and brittle kind of iron.

The second variety of specular iron ore, is the red and granular, which always occurs between the gneiss and potsdam sandstone, and constitutes by far the largest part of the valuable ores for the manufacture of iron in Jefferson, Lewis and St. Lawrence counties.

From reliable statistics collected from the proprietors of the several mines, it appears that about 200,000 tons of this ore have been raised and smelted since the erection of the first furnace in 1813. A general average for a series of years shows the yield of iron to be about fifty per cent. The constant associates of this ore are calcite, quartz in small slender crystals, and dysyntribite.

Of less constant occurrence are spathic iron, iron pyrites, cacoxene, heavy spar, and millerite.

So uniform is the connection of dysyntribite with the red oxide of iron, that in no instance have they been observed separately in any of the mines which have been wrought in northern New York. This fact has been observed by practical miners, and in several instances have successful undertakings been commenced, without a previous knowledge of the existence of ore further than was furnished by the presence of this associate.

8. ON THE EQUIVALENCY OF THE ROCKS OF NORTH EASTERN OHIO, AND THE PORTAGE, CHEMUNG AND HAMILTON ROCKS OF NEW YORK. By CHAS. WHITTLESEY, Esq.

IN Ohio, from the National Road south to the River, or southern boundary of the State, the space indicated in our caption is occupied by few and easily recognized formations.

The downward section is every where uniform. First—"*Conglomerate*" supporting the coal. Second—*Fine grained*, or "Waverly" sandstone. Third—*Black shale*. Fourth—*Buff colored*, or "Cliff limestone;" these being the terms of description used in the Ohio Reports.

The color, grain, bedding; in fact every external characteristic of each of these formations is unlike every other. The lines of junction are distinct, and the beds very regular. So far as lithological marks are concerned, no person would hesitate a moment in deciding when he had reached the limits of any one of these formations. When the Ohio Survey was suspended in 1838, little was known respecting these fossils; and since that period, very little progress has been made. Fossils are too scarce to supply this deficiency with much rapidity. In 1842, Mr. Hall of the New York survey, made a reconnoissance of the western rocks, and after some examination of the fossils of the fine grained or waverly sandstone, suggested a division of it into two formations. This had never occurred to the Ohio geologist, for two reasons. The southern half of the state was the principal seat of their examinations, and here it is by no means certain that a division is called for, on the rules of paleontology. The fossils are meager indeed, and at this hour unstudied. The external characters are marked, and throughout each formation, uncommonly persistent.

The border of the primary region of St. Lawrence and Jefferson counties affords a favorable opportunity of studying the relation of the white limestone to the potsdam sandstone, and in no instance has the latter been observed below the former.

In several localities has the limestone been observed between the sandstone and gneiss, with indications that it is intermediate in age between the two.

This white limestone is of interest to the mineralogist, as being the repository of many of the more rare and elegant species of minerals that occur in this section of New York.

This furnishes an opportunity of noticing a series of associations which tend to confirm facts that have been remarked in other parts of the Union.

Among the species which are found in no other rock in this region, are the following: Scapolite, phlogopite, apatite, zircon, loxoclase, brown tourmaline, pyroxene, chondrodite, and spinelle.

The last two mentioned minerals had not been observed in quantity north of the great primitive region of New York, previous to the spring of 1850, a fact that was considered remarkable since the other mineral associates of white limestone were strikingly similar to those of Orange county, New York, and certain localities in New England where chondrodite and spinelle are common.

In March, 1850, the writer discovered a locality of the former in the town of Rossie, St. Lawrence county, in which this mineral was disseminated through the limestone in the greatest abundance, and over a considerable tract of country. This was soon followed by the observation of small rose colored crystals of spinelle, disseminated through the rock, in rare instances attaining the diameter of three-fourths of an inch.

The association of pargasite with scapolite and pyroxene, of apatite with zircon, and of serpentine and rensalaerite with white limestone, is also very constant.

Many of the facts above enumerated were previously well known, and similar associations have been remarked in other instances. Their occurrence in this section may tend to confirm the observations of others, and serve to establish some of the general principles which govern the distribution of mineral substances, and ultimately lead to a knowledge of the *causes* that may have operated to produce them.

The Black Shale, a dark laminated argillaceous and bituminous schist, with septoria, has no fossils—at least I never saw or heard of more than *one*, which was found near its surface, in Franklin county, and resembled a Lycopodia.

This "Black" shale rests on the non-laminated, thick-bedded, buff-colored limestone; replete with fossil shells, and some crustacea. Above the shale, is the fine-grained, greenish-gray sandstone, called, provisionally, the "Waverly;" bedded in flags, (such as are used on the sidewalks of Cleveland,) and quarry stone; with true and smooth faces; having ripple marks; and alternate, thin bands of argillaceous, light-colored shale between the flags. On it rests the iron-stained,

yellowish, coarse-grained, pebbly sand rock, or "conglomerate." To the eye, nothing can be more different than these rocks, and in stratification, they do not incline to mingle their beds.

In that portion of Ohio *north* of the national road, as we proceed along the strike of these beds, towards the New York rocks, a change is observed, and a tendency to separate into members; the fossils become more plenty, and new beds introduce themselves. It was in this portion, (especially from the State line westerly along the Lake shore, and the bluffs of the Cuyahoga river to Akron,) that Mr. Hall made his principal examinations; and, no doubt, correctly, came to the conclusion, that there should be more divisions than the Ohio Reports recognized. It was also precisely in this most interesting, and most complicated geological field, that, owing to the sudden close of the survey, the last work was done. The few fossils collected were not at that time examined, and the most that could be exhibited in the second Report, was a physical section along the dip, showing the succession and thickness of the individual beds, separated lithologically from Cleveland south-easterly to the corner of that part of the State of Ohio called the Reserve. At that time, (1838,) the splendid results of the New York survey had not transpired; consequently, even with all the European researches before us, it would have been a protracted labor to arrange the strata of north-eastern Ohio into their true geological families.

Neither can it be done at this moment, for the want of fossils, and of examination. My present intention is merely to show the relation of these rocks to the New York formations, of which they are evidently the disappearing remnants, thinning out towards the west. I say the "relation," although with many of them it is yet difficult to discover any connection, but rather a want of it. This discrepancy is probably more apparent than real; for in distances so short, as from *Chatauque county*, New York, to *Cleveland*, Ohio, on which there are no breaks in the strata, and very little dip, we should anticipate little change in geological position.

On the south-west, we have the researches of Dr. Owen, Dr. Locke, Dr. Yandell, Dr. Shumard, and others of equal industry. The rocks from the cliff, as shown at the Falls of the Ohio, upward to the coal, have been much studied by these gentlemen; and the results thus far have been, instead of order and equivalency, confusion and discrepancy. There is little agreement with the New York rocks, and by

no means a perfect agreement with the European systems, as the examinations stand at the present time. Perhaps a *comparison* of the various opinions hitherto elicited, in reference to the equivalency of the rocks above the cliff and below the coal, as exhibited in New York, in Ohio, and in Kentucky, may be of future use in reconciling the doubts and contradictions that now exist.

The object of this paper is more to point out the differences to be reconciled, than a solution of the difficulty. It will be something towards a solution, to present the true questions to be settled. It will make the comparison more distinct, to take the *Conglomerate* as the starting point, and give *downward sections* from that rock, whose position admits of no doubt.

SECTION OF THE ROCKS OF CHAGRIN FALLS, O., eighteen miles east of Cleveland, from the Conglomerate *downward*.

1st. *Conglomerate* or pebbly sandstone, the base of the coal series, Lower Fall, 489 feet above Lake Erie.

2d. *Soft Ash-colored Shale*, thickness 110 feet; weathers easily into a light yellow, tough clay; breaks at joints into small pieces; has a *few* bands of fine-grained sandstone, 5 to 8 inches thick. Near the bottom, saw an impression *apparently* part of the buckler of a Trilobite, not distinct; and a vegetable belonging to the Graminieæ.

3d. *Yellowish-green, argillaceous, soft, fine-grained Sandrock*, thickness 15 feet; tinged by sulphur, argil, and iron; in beds and flags, 1 inch to 18 inches, with beds of thin shale intervening.

4th. *Black Shale*, thickness 13 feet; upper part tender, lower part tough and slaty; near bottom, thousands of *Lingula spatulata, and Orbicula lodensis;* also fragments resembling Gramina, and another resembling a *Cyclopteris*—none of them distinct.

5th. *Coarse-grained Sandstone*, or "*Grindstone Grit*," thickness 38 feet; in flags and regular beds, with smooth faces; ripple marks very perfect; 2 inches to 16 inches thick; good quarry stone and grindstones; *fossil fish* about 10 feet from surface. This bed is nearly horizontal along the Lake shore; its out-crop being at the first rise above the Lake ridges; it is seen at Euclid, Newburg, Independence, Brandywine Mills, Peninsula, Middlebury, Elyria, and Brownhelm, Lorain county, Ohio. The east pier of the Harbor of Cleveland, and the Marine Hospital, are built of this rock.

6th. *Brownish and Greenish Shales*, with numerous bands of hard, close, *fine-grained sandstone;* these lie in beautiful flags, with ripple marks, and beds from 1 to 18 inches thick; some soft, argillaceous, and weathering to an iron color; others hard, close, and flinty. The argillaceous and ferruginous beds peel off at the angles, in concentric segments, forming rounded edges. Thickness not known—probably 400 feet, to cliff limestone.

Following the Chagrin river below the Falls, to the Lake about 20 miles by the channel, the member No. 6 is seen all the way, consisting of alternate thin beds of shale, ironstone, and sandstone. The same section of the same rock is seen in the valleys of the Cuyahoga, of Rocky river, Black or Vermilion, and Huron—the relation between the quantity of shale and sandstone varying very much. In places, as on Mill creek, a tributary of the Cuyahoga, there is a thickness of 20 and even 40 feet of hard black shale, without layers of fine-grained sandstone, or ironstone. In these frequent changes of composition, we recognize a characteristic of the upper rocks of the 4th District of New York. A few miles west of the Huron river, and about 60 miles west of Cleveland, it rests on the buff-colored or cliff limestone of Ohio. This space between the "grindstone grit" and the "cliff," embraces the waverly sandstone, and the "Black Shale" of the Ohio Reports. But here, what portion should be called "waverly," and what, shale, is not easily determined.

In the southerly part of the State, the termination of each formation is apparent. In a section which will be given below, taken at Newburg, near Cleveland, a thickness of 25 feet of tolerably compact, fine-grained or waverly sandstone will be seen. Above the thick-bedded portion is 15 to 17 feet of *flags* of the same stone, separated by thin beds of shale. At Kingsbury Quarry, and at Newburg Mills, on Mill creek, immediately below the thick-bedded sandstone, is a shale, or slate that could not be distinguished from the black slate beneath the waverly, at Columbus and Chillicothe. But on the Ohio canal, at Boston Peninsula, 20 miles south of Cleveland, the thick beds are much more dispersed; and the shale below is soft and greenish, with bands of ironstone; and the same on Rocky river, Vermilion river, Chagrin and Grand rivers, and on Conneaut creek, near the Pennsylvania line. I am able to give a detailed section of about 100 feet of No. 6, beginning at the inferior face of the "grindstone grit, and counting *downwards;* it is taken in the valley of Big Brook, a small

tributary of Chagrin river, in the township of Orange, Cuyahoga county:

1.	Brown Shale, - - - - - - - - -	20 feet.
2.	Quartzose Sandstone, - - - - - - -	1 "
3.	Shale, - - - - - - - - - - -	12 "
4.	Close, fine-grained Sandstone, (fossil shells in great numbers, - - - - - - - -	2 "
5.	Shale, with bands of Sandstone, - - - - -	20 "
6.	Close, hard, fine-grained Sandstone, - - - -	$1\frac{1}{2}$ "
7.	Shale, with bands of hard, close Sandstone, - -	25 "
8.	Solid Shale, with thin beds of Ironstone, - -	15 "
		$96\frac{1}{2}$ feet.

At Kingsbury Quarry, in Newburg, about 12 miles north-west by west of Big Brook, the section is materially different; thus, from grindstone grit, downwards—

1.	Red Shale, (homogeneous,) - - - - - -	16 feet.
2.	Blue Shale, with flags of fine-grained Sandstone, -	27 "
3.	Thick-bedded Waverly Sandstone bottom, 168 feet above Lake Erie, - - - - - - -	25 "
		68 feet.

I will here introduce a tabular view of the rocks from the Conglomerate, downwards, as seen in New York, Pennsylvania, Ohio, and Kentucky.

EXHIBIT OF THE STRATA IN NEW YORK, OHIO AND KENTUCKY, RECKONING FROM THE "CONGLOMERATE" DOWNWARDS TO THE "CLIFF LIMESTONE."

NEW YORK.	OHIO.	KENTUCKY.
Hall's Reports—Chatauque county, 1,600 and 1,700 feet above Lake Erie—classified by fossils.	Chagrin Falls, 18 miles east of Cleveland—classified by external characters—base of conglomerate 489 feet above Lake Erie.	Falls of Ohio—by Drs. Yandell and Schumard—arranged by fossils.
1. *Old Red Sandstone*, very thin, Holoptychus nobilisimus, Sauropteris Taylorii.	1. *Ash Colored Shale*—110 feet, soft, with few bands of fine grained sandstone.	1. *Carboniferous Limestone*, cavernous—Mammoth Cave.
2. *Chemung Group*—1,200 to 1,500 feet thick—green, olive and black shales, and gray sandstones — fossiliferous — Delthyris, Atrypa—Strophomena—Septaria.	2. *Thick bedded*, soft, fine grained argillaceous sandstone, 13 feet.	2. *Button Mould Knobs*—fine grained sandstone, crinoidal limestone—carboniferous.
3. *Portage Group*—Thick bedded sandstone, fine and coarse grained—shales—flags, thickness, 1,000 feet.	3. *Black Shale*—13 feet—towards base, slaty and fissile—Lingula spatulata—Orbicula lodensis.	3. *Bituminous Black Slate*—Lingula concentrica—Orbicula lodensis—104 feet. In Tennessee, by Drs. Owen and Norwood—also, Lingula spatulata, 51.8 feet.
4 *Genessee Slate*—Argillaceous fissile, black slate—Avicula fragilis—Orbicula lodensis, Lingula spatulata and concentrica—Strophomena setigera—23 to 150 feet.	4. *Grindstone Grit*—38 feet, coarse grained sand rock thick bedded and in flags—ripple marks—fishes.	4. *Encrinital Beds*—8 feet.
5. *Tully Limestone.*	5. *Fine Grained Sandstone*, thin and thick bedded ("Waverly") with red, blue or green shales interstratified—flags and ripple marks—stripes of ironstone, and iron rust with fossils. Lower part—"black slate" of Ohio Reports, thickness to Cliff limestone, probable 400 feet. See remarks and section below—embraces Nos. 3, 4, 5, 6, and 7, of New York column.	5. *Water Lime Beds*—12 feet.
6. *Hamilton Group*—highly fossiliferous—septarian—olive and dark shales—Trilobites—Cystiphylla—Strombodes.		6. *Shell Beds*—16 feet—compact subcrystalline light gray limestone—"corniferous."
7. *Marcellus Shale*—external characters and fossils similar to Genessee slate.		7. *Coralline Beds*—40 feet—upper and lower.
8. *Corniferous Limestone.*		8. *Catenipora Beds*—C. escharoides—"Niagara."
9. *Onondaga Limestone.*		9. *Pentamerus Beds*—P. oblongus—"Blue limestone," "Clinton," "Carodoc."

I have, for the purpose in hand, regarded the "coarse-grained sandstone," forming the base of the coal in western Kentucky, as the equivalent of the conglomerate; although I am not aware that the fossils of this sandstone have been found in our conglomerate.

These consist of Crinoidea, Terebratula and fishes. The Pennsylvania column* embraces only a portion of the beds between the conglomerate and the cliff, but in the absence of a final report, is the best section at command. From it little can be inferred on the subject of equivalency. The old red sandstone can scarcely be said to exist in western New York, as it dwindles to a mere representative of that rock soon after we pass the Genessee river. No one has reported its presence farther west. We are now prepared to contrast more minutely the various beds represented in our table.

In the early part of the investigations in New York, the *Chemung* and *Portage* groups were thought, though not with the greatest confidence, to be *Silurian.*

Mr. Hall, after examination, felt no hesitation in pronouncing the changeable beds, included in No. 5 of the Ohio column above given, to be the Chemung, Portage, Hamilton group, and Marcellus shale. The black shale overlying the cliff limestone at Columbus, Ohio, and also found at the Falls of the Ohio river, resting upon the calcareous beds of that region, he had no doubt were the *Marcellus shale.*†

In Indiana, his Chemung group supported a group of *gray* sandstones and limestones; the latter having an oolitic structure. This group was at the base of the conglomerate of the coal series, and the group itself confessedly *carboniferous.* Thus the Devonian and old red would be wanting about the Falls of the Ohio, and the upper silurian would abut directly upon the carboniferous. But more investigation induced the New York geologists to cut off the rocks from the *Hamilton* (including a part of it) to the old red; from the silurian strata and attach them to the Devonian.

At the same time the western geologists were prying into the paleontology of the lower Ohio river, and concluded that the "black slate" of the Falls (the Hamilton of New York,) was certainly Devonian, and with it some of the beds of the cliff limestone.

No. 7 of our table, called the "Coralline Beds," is by Drs. Clapp, Yandell, and Shumard, divided as follows: "Upper Coralline," 20

* (Omitted by direction of the author.)

† Geology, Fourth District, pp. 501, 502, 503.

feet; "Lower Coralline," 20 feet. In 1847, M. Verneuil spent some days in the vicinity of Louisville, and determined to fix the line separating the Devonian and Silurian strata, between the *upper* and *lower* Coralline beds of the Falls, thus sinking it still lower in the column.

Of *twelve* species, which are next below this line, *seven* are common to the Silurian and Devonian, and *five* are Silurian.

Of twenty species belonging to the upper beds, *ten* are common to the Silurian and to the Devonian, and *ten* are exclusively Devonian.

There are fossils also in the upper part of the "Cliff" at Columbus, Ohio, that are Devonian.

The shell beds of the Falls of Ohio, are, by all, regarded as identical with the "Corniferous" of New York; and, therefore, the base of the Devonian in New York is certainly *as low* as the Onondaga limestone.

In the plate which accompanies this memoir, are drawings of such of the fossils of my cabinet, collected in northern Ohio, as belong to the geological space under consideration, which I am not able to identify.

Also, an undescribed fish, from a specimen belonging to Jehu Brainerd, from the "grindstone grit."*

These figures, together with the physical sections I am able to present, are offered with a view to assist those who are investigating the equivalency of the western rocks, under better circumstances, both in the United States and in Europe.

Mr. Hall unhesitatingly pronounces the fine-grained sandstone at Newburg, near Cleveland, and the Waverly of the Ohio Reports, to be a member of "Portage group." In arranging the rocks of Cuyahoga, and the adjacent counties, by external characters, as we are yet compelled to do, in the absence of a paleontological classification, I select as a guide, or starting point, those that are most striking and persistent. These are the "conglomerate" and the "grindstone grit." They are easily identified, because they are *coarse-grained*, and are surrounded, above and below, by *fine-grained*, argillaceous, or shaly beds. In the New York Reports, I do not recognize our grindstone grit.

Its lower face, at Chagrin Falls, is 315 feet above the lake at Newbury, (Kingsburg,) 228 at Bedford, Cuyahoga county, 282 at the Peninsula on the Ohio Canal; 25 miles south, it is 178; and at Elyria, 24 miles west of Cleveland, about 90 feet, descending or thickening downwards to the west and southwest.

* See Report of Prof. Agassiz.

The inferior face of the conglomerate in New York, is, in Chatauque county, about 1,700 feet; at Meadville, Pa., 955; at Russell Center, three miles above Chagrin Falls, 489; and at the Old Forge, near Akron, Summit county, 443. The line of outcrop of this rock, therefore, *sinks* as we proceed westerly from New York, and the subordinate rocks thin out at about the same rate, that is to say, from about 2,800 feet to about 750.

At Kingsbury's quarry, Newburg, the local section next below the grit, is somewhat different from that at Chagrin Falls, to wit:

Section at Kingsbury's Quarry, (downwards.)

1. *Red shale*—surface same as base of grindstone grit, or 228 feet at Lake Erie—thickness, 15 feet.
2. Greenish-blue shales, and thin fine-grained flags—used at Cleveland for side-walks—27 feet.
3. Thin and thick bedded, fine grained sandstone—"Waverly" of Ohio, and "Portage" of New York—25 feet.
4. Black, bituminous, tough slate—surface 160 feet above Lake Erie, and extending beneath its surface.

The red shale is occasionally seen beneath the grit to the westward, for 40 miles, but in places is wanting. I know of no fossils in the red shale, a material which is now extensively used as a coarse *paint*, being simply ground in a mill like plaster, and bolted. In fact all the shales of the Western Reserve seen, black, green, and red, both of the coal series, and of the rocks below, are now ground, bolted, and sold as "mineral paint," in Ohio and New York. Mr. Blake, of Sharon, Medina county, was the first person who turned the shales to that use. Some of them give an agreeable color, and are much used for out houses and roofs. The finest in grain, and those which contain the greatest portion of magnesia, are preferred.

The rocks in northern Ohio, between the "grit" and "cliff," might well be named the "Protean group," their externals change so frequently. At Newburg Falls, the thick bedded, fine-grained sandstone rest on the tough, black slate, seen at Kingsbury, and which is like that seen at Columbus, Ohio. At the Peninsula in Boston, about 20 miles up the valley of the Cuyahoga river, and at Bedford, Cuyahoga county, the beds beneath the thick bedded, fine-grained sandstone, are of soft, blueish shale, with thin bands of iron ore, and sandstone flags Such is the general composition on the Chagrin and Grand rivers,

east of Cleveland; also, on Cuyahoga, the Rocky, the Black, and Vermilion rivers. Below the Falls of Black river, at Elyria, the shale is, in places, red; in others, dark and tough. My impression is, that the "grit" wedges out and disappears soon after it passes beneath the conglomerate to the southward.

I will now give the fossils known to me as having been found in each of the divisions in the Ohio column of the table of formations.

No. 1, or first below the Conglomerate.

NAME OF FOSSIL.	LOCATION IN OHIO.	CORRESPONDING FOREIGN ROCKS
Fucoides graphica,	Near Akron,	Portage group, New York.
Delthyris inermis,	" "	Chemung group " "
Atrypa laticostata,	Weymouth, Medina co.,	" " " "
Clymenia complanata,	" " "	Portage " " "
Strophomena pectinacea,	" " "	Chemung " " "
Pleurotomaria Lloydi,	" " "	Lower Ludlow.
Strophomena octostriata,	Akron, Summit county,	Chemung group, New York.
Ungulina suborbicularis,	" " "	Portage " " "
Plate, figs. A and A a,		" " " "
Plate, figs. B, B b and B,*	Weymouth,	" " " "
An undetermined shell like a Pileopsis, and another like a Pleurotomaria,	Weymouth,	" " " "
Atrypa lentiformis,	"	Tully limestone.

No determined fossils have as yet been seen, at Chagrin Falls, in the "ash colored shale," but the imperect forms remaining show their existence for future discoverers.

At Akron and Cuyahoga Falls, the beds next below the conglomerate embrace a stratum of water lime, which was used in the construction of the first flight of locks from the Portage Summit northward. Here Mr. Hall identifies the rocks as of the Chemung group, and observed Strophomena, Atrypa, Cypricardia, Orbicula and Lingula.

No. 2—Thick bedded, fine-grained sandstone—no distinguishing fossils.

No. 3—*Black shale,* Chagrin Falls, Lingula spatulata, and Orbicula lodensis; fossils of the Genessee slate of New York, and of the black slate of Kentucky and Tennessee.

No. 4—*Grindstone grit*—fossils, only the fish shown in our engraving, its tail heterocercal.

No. 5—includes all below the grit to Lake level. Shales, sandstones and flags.

FOSSILS.	LOCATION	CORRESPONDING FORMATIONS.
Bellerophon globatus,	Big Brook, Orange, Cuyahoga co., Ohio,	Old red sandstone.
Goniatite—see plate,	Big Brook,	" " "
Atrypa laticostata,	" "	Chemung group.
Cucullea antiqua, (?) See plate *C*, *C*, *C c*,	" " and Bedford,	Old red.
Plate *E*,	" "	" "
" *D* and *D d*,	Northfield, Summit co.,	" "
" *F*, *F f*,	" " "	" "

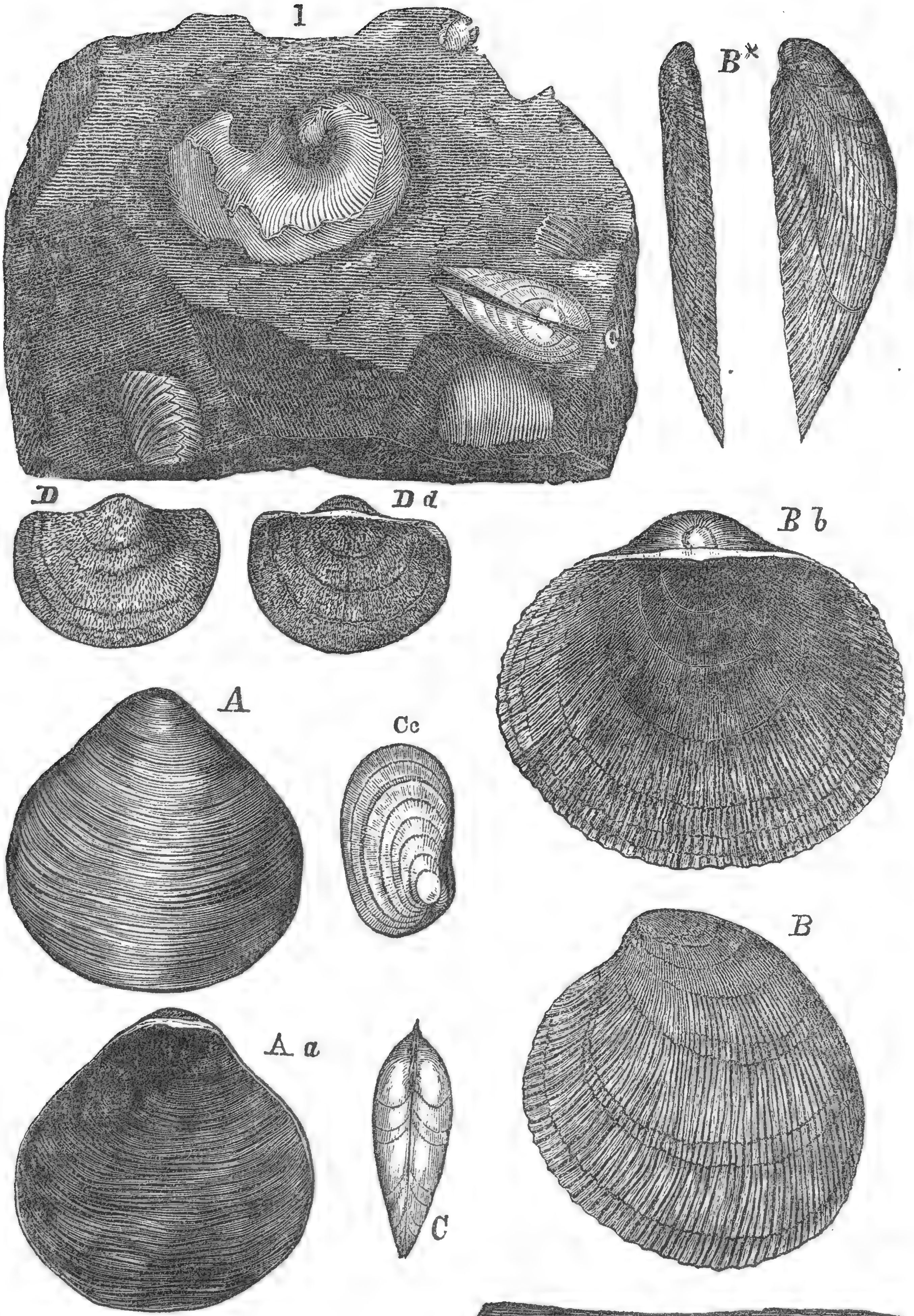
The shells represented in the plate, page 220, are given to make the reader as fully acquainted with the fossils of the rocks between the conglomerate and the "cliff," in northern Ohio, as those who reside here are at this time.

The engravings represent all the shells within my knowledge, which I do not recognize in the few works to which I have access. Having just given a list of all the shells hitherto found, including those here figured, by reference to the works on the corresponding rocks, for such as are not in the plate, the reader may study our rocks, with all the helps we possess, on the spot, and probably with better geological works and illustrations.*

The Lingula and Orbicula, of the black shale, were first discovered by Mr. Brainerd; and we owe to his care the preservation of the splendid specimen of a fish, from the grit, of which we give a reduced figure. It was first noticed by Mr. Hiram Gleeson, while working a quarry. Mr. E. Russell, of Chagrin Falls, has assisted Mr. Brainerd and myself in our collections.†

* Several of the fossils given as belonging to our rocks, were collected by Mr. Brainerd, the artist who drew and engraved the shells here represented. Whoever examines these can rest assured, that they are, as far as they go, faithful representations, for Mr. B. is a close student of natural history, as well as an artist; and feels the necessity, which a mere artist seldom does, of giving the minute characteristic markings of an object, rather than a general picture.

† After the proofs were taken, both of us compared the impression with the fossil before us, and corrected every thing essential to a good understanding of the figures, except the shell *F*, *Ff*, where the radiating lines are too prominent when contrasted with the concentric lines.


1
B*
D
D d
B b
A
Cc
B
A a
C
E
G
2
F
Ff

Explanation of Figures.

The goniatite, fig. 1, is an exact copy of the specimen, neither restored nor diminished, and is like all of the others, of the *natural size.*

Fig. 2 shows the same entirely divested of its shell, with very distinct oblique waving lines—the mouth wanting. The fine parellel lines of the external surface of the shell are equally distinct, and directed toward the mouth, nearly at right angles to the markings of the internal surface. On the back is a ridge or line, very true and well defined, from which the lines of the outside of the shell depart, in acute and equal angles. The point, or inner termination of the coil, is in the plane of the shell, but does not touch it. This specimen is the only one I have seen. It was found at Sheldon's saw-mill, about one mile east of the center of Orange, Cuyahoga county, Ohio, in a ledge, at the Falls of Big Brook, and not more than 25 or 30 feet below the "grit." It lay on the surface of a thick layer of fine-grained sandrock, which had about an inch of very hard ferruginous cement, making it almost impossible to cut away from the fossils and develope their form. The shells here are very numerous and well preserved; and I have observed throughout the field from which these are procured, that fossils are very scarce, except in places where there is iron rust seen between the layers. The oxide has evidently acted as a preserver to animals whose bodies would otherwise have been decomposed before the impression was made on the rock.

C C and *Cc*, are different views of a beautiful equi-valved shell, very numerous and very perfect, that lies from 25 to 40 feet below the "grit," at Bedford and Orange.

C, of figure 1, is a back view, partly open; *C*, the same from the Bedford shell, closed; and *Cc*, the internal view of one valve.

With the exception of the crenatic hinge, it compares closely with the shell figured in Murchison, Plate III, fig. 12, *a*. The artist has in the drawings, superseded the necessity of dwelling longer on this perfectly symmetrical and elegant mollusk.

B is the downward external view of the dorsal valve of a shell found in great numbers at Weymouth, Medina county, about 80 feet below the conglomerate, and of which *Bb* is the internal view. The radial lines are not continuous from back to front, but wrinkled, and sometimes branching, exactly as sketched. *B** represents a side view of both valves, all of the size of nature. The two are never found

together, although hundreds of the shells may be found in the same square rod, mingled in confusion. It has not yet been seen at any other place than Weymouth, which is situated on the west branch of the Rocky river; and they are most abundant near the mills of Mr. Ferris Stiles.

E is an unknown shell, of which all that has yet been seen is represented. Neither the hinge nor the internal view can be seen; and in the ferruginous portion of the sandrock, the fracture, if we try to expose a shell, is as likely to go through as along the fossil. It is probably a bivalve, of which this is the dorsal, with an incurvated beak and a short hinge, and is gibbous. A small one is shown at the left hand corner of figure 2, in the same position. These are the only ones seen, and they are in the same specimen with the goniatite from Big Brook.

The shell *A Aa* is from near Akron, half a mile west of Lock 19, and about 40 feet below the conglomerate. Only one valve has come to light, of which an internal and external view is given. It appears to be the *Ungulina suborbicularis* of Hall, 4th District, page 154, of the Portage group.

On the lower left hand corner of figure 1, is the front of an *Atrypa laticostata,* a shell ranging from above to below the grit.

The open shell, on the right hand upper corner of figure 2, is the same as *C,* of figure 1, only more spread.

G is an external view of a single valve from the locality of *B Bb.*

The hairy looking shell *D Dd,* was found in Northfield, below the grit; only one valve seen, which is represented in the drawing, from within and without, with great fidelity.

F Ff are two views of a single valve, from the same spot, and about 40 feet below the grit. In the specimen the concentric lines are rather more bold, in comparison with the radiating ones.

At the right hand upper corner of figure 1 is a small shell, presenting its front, which may be taken for the young of *A,* but is more regular and symmetrical in form. It is from the Big Brook locality, some 25 miles distant from *A,* which is below the grit; while that shell is higher in the series, near the conglomerate.

I believe the engraving of the *fish,* (see Agassiz's Report,) here shown, gives not only the correct air or expression of the specimen, but all the details, as far as they are traceable. Only three have been found; of these, Mr. Brainerd has one, and the cast of another, which remains in a stepping-stone, at the door of a high school or academy,

at Chagrin Falls. The third specimen is said to have been found some years since, about two miles distant; all of them about ten feet from the surface of the grit, and all nearly of a size. No other fossils of any kind have as yet been sesn in the grit, although it is an extensive formation, and is quarried in more than an hundred places. The drawing is reduced to about one-fourth the original size, which is $11\frac{3}{4}$ inches in length. Its pectoral fin is plainly seen, but somewhat crushed and injured, so as to destroy the outline, in part. The gill is also visible, but distorted, being neither more nor less distinct in the figure. It is not practicable, to a person not conversant with fossil fishes, to give a conjecture of the structure of the head, except that the size and length of the under jaw are evidently shown, and are very great, in comparison with the body. The fins are apparently thin, flat, and the rays membranous; they are straight and parallel, and so finely marked as not to be readily counted. Those of the caudal fin are between 60 and 63; of the dorsal, 14 to 16; of the ventral, 16 to 18; and of the pectoral 30 may be seen, but these are not the whole number.

The jaw of a fossil fish was found, by D. Christy, Esq., near the surface of the cliff limestone, Delaware county, Ohio.

As I have shown in other parts of this article, the preponderance of authority is now such as to render it almost certain, that the cliff limestone, in which this fossil is found, belongs to the Devonian system.

In the same rock, at Columbus and at Sandusky, teeth of the shark have been found.

9. ON QUARTZ PEBBLES, OF THE SANDSTONE CONGLOMERATE, AND REASONS FOR REJECTING THE THEORY OF "WATER DETRITION." By Prof. J. BRAINERD, of Cleveland.

THE geological position of the conglomerate, is generally, immediately below the coal series. The formation contains vegetable impressions of plants of the coal epoch. In the location from which the accompanying specimens were taken, the calamites predominates. (Geauga Co., Ohio.)

1st. There appears to be no primitive formation of Quartz Rock, adequate to furnish a supply.

2d. Admitting that the injected quartz veins, of the primitive form ations, are adequate to furnish the necessary quantity, the structure of the rock proves it to be from a different source. Specimen No. 1, is a quartz boulder, from the primitive rock. No. 2, is a quartz pebble from the conglomerate. The former is highly crystalline in its character, a feature common in primitive formations. The latter in its internal structure, is more glassy or vitreous, and often contains small cavities lined with oxide of iron, as in the specimen. In some respects these pebbles resemble the nodules of flint found in chalk, and I would suggest that the origin of the two may have been similar.

3d. Were the pebbles of the conglomerate water worn fragments from the primitive rock, the conglomerate should contain other fragments than qnartz, other portions being equally indestructable and as abundant.

4th. If the pebbles of the conglomerate are transported, and water-worn, by what process have they been deposited in the interior portion, or chamber stalk of the calamite? Such examples are common, where no fracture of the stalk is shown.

5th. If they are transported and water worn, by what means have the impressions of vegetables been stamped upon the surface, as though the pebble had been in a soft or plastic state? This feature is finely exhibited in the accompanying specimens.

All specimens when first broken from the mass, present under the microscope a similar impression of the finer grains of sand. The conclusion seems inevitable that this formation is the result of a semi-crystallization, from water highly charged with silicious matter in solution.

10. On the Character of the Vegetation of South Western Texas. By Dr. George Engelmann, of St. Louis.

The flora of the immense territory of the United States bears a peculiar common character, distinguishing it from other regions of vegetation. This character consists in the prevalence of some families, and more especially of the *Compositae*, of the occurrence of others only in this part of the globe (e. g. *Magnoliaceæ*), and in the great number of species of many genera known in other countries only by a few living representatives or among the fossil remains of the brown coal (tertiary) formation. Such genera are the oaks, the pines, the horse chestnuts or buckeyes, the maples the grape vines (*Vitis*), the birches, the walnuts and hickories. The magnolia, the gleditschiae and the sweet gum (*Liquidambar*) are in Europe only found among the fossils. Herbaceous plants exemplifying this character are the asters, solidago, helianthus, asclepias, etc.

But as we may naturally infer, this large territory shows different regions of vegetation, produced or influenced by climate, conformation of the surface, geological character of the soil, and perhaps other causes not so readily appreciable.

Such different areas are the north-eastern Alleghanies and their slope to the Atlantic; the southern part of that mountain range and its eastern slope to the ocean; the sub-tropical region of Florida, so different from that of Texas though in the same latitude; then the western slope of the Alleghanies towards the immediate valley of the Mississippi; the northern and the southern part of that valley itself, the latter including north-eastern Texas; again the region of the western plains and deserts; that of the Rocky Mountains, of the Pacific coast, and finally the peculiar flora of southern Texas, or of the Rio Grande valley.

Though I have never explored that country myself, the extensive and beautiful collections of my friend Ferdinand Lindheimer, together with his very full notes, enable me to attempt a sketch of the character of that flora.

And I here take the liberty of again reminding you of a remark made from this place a day or two ago by one of our highest authorities, in speaking of palæontological collections, and which can not be too often repeated and inculcated, that is: it is not only the collected specimen itself, which is valuable, but the notes, the data in regard to exact locality, association with other forms, and all circumstances

tending to enlighten us in regard to it, are absolutely necessary to give to the specimen its full value.

South-western Texas, as I regard it, to judge by the character of its vegetation, has its natural boundaries to the north-east on the Brazos, or more properly between this and the Colorado river; to the south-east in the alluvial plains which extend from the Gulf coast into the interior, and which bear more the character of a sub-tropical vegetation; to the south and south-west by the Rio Grande, or most probably by the northern slope of the Mexican table land south-west of that river; and to the north-west by the mountains and plains of New Mexico.

The geological character of this country is well known through the investigations of Prof. Roemer, to which the notes of Lindheimer's and others have added some details. The whole of this country with slight exception, is of cretaceous formation; the rocks are calcareous, with cherty mixture, and of horizontal stratification, rising in several plateaus or terraces one above the other, over the alluvial lands of the sea coast; the plateaus often with steep declivities, and not rarely broken up into level topped hills with terraced slopes. The rivers and brooks are clear streams often with wide, shallow, gravelly beds, which becoming dry, are exposed a great part of the year, and having on many places perpendicular rocky banks. Along the fertile margins of the larger streams the usual forest trees of the southern States are found, not unfrequently also with the cypress (*Taxodium distichum*), and on the slopes, fine cedar woods (*Juniperus virginianus*) frequently close the view; other pine trees are unknown in this district. On the thin soil of some parts of the country, scattering post oak woods occur, but on the whole larger timber is scarce.

The climate is mild, not too warm in summer, in fact it is said to be not as warm as that of the central portion of the Mississippi valley is from June to August; in winter occasionally ice is seen, but quickly disappears. Farther to the northwest the extremes are greater, and in the southern part of this region frosts are unknown. Spring opens with February, rains occur at that time and often as late as May and June; a season of general draught follows until the September rains again revive the vegetation. It is then that early flowering shrubs often once more begin to blossom, and many annuals again sprout up and bear flowers for the second time, assuming an almost ligneous stem and apparently perennial root, so that it sometimes becomes difficult to decide whether they really are annuals. Some plants, the

representatives of which farther north, blossom in spring, put forth their flowers only in September or October; as *Oxalis vespertilio,* the near relative of the common *O. violacea;* and *Ulmus crassifolia,* closely allied to *U. alata.*

As we may expect, the Flora of south-western Texas partakes to some extent of the character of the vegetation of the adjoining districts. We find there the œnotherae and gaurae, the Buffalo grass, and many other plants from the northern plains. The now well known Compass Plant of the prairies (*Silphium laciniatum*) is also found there.* The western mountain region sends down to the calcareous plateaus a number of grasses. *Yucca angustifolia,* some *Portulacaceae, Nyctaginaceae,* and many others.

From the table lands of Mexico, and particularly its northern slopes, we find in the region we have now in view the *Bolivariae,* some *Malpighiaceae,* some *Zigophyllaceae,* besides the *Mimoseae* and *Cactaceae,* to be mentioned more fully hereafter; mostly genera or families not found farther north or east, but species not occurring further south.

Many herbaceous plants of different families are quite peculiar to that country. Of these I will mention only *Rutosma texanum,* which with *Peganum mexicanum* (A. Gray, mss.) found south of the Rio Grande is, in America, the only representative of the Rue family. So are the congeners of the remarkable *Hermannia texana,* common only in South Africa.

But the striking character of the vegetation of that region consists in the diminution of trees into shrubs; they do not disappear entirely as in the western plains and deserts, which extend into north-western Texas; nor are they generally the same species which elsewhere grow up to be large trees, reduced in size; but shrubby species, peculiar to that region, represent the larger trees of the same or analogous genera of the more northern parts of the country.

The stately walnut trees of your forests are there reduced to the

* Note.—It is perhaps not without interest to learn, that Mr. Lindheimer has, with the compass, verified the so called polarity of the radial leaves of this plant. I have no doubt but that sunlight is the determining cause of this peculiarity, as my friend Mr. J. A. Lapham of Milwaukie has suggested. But whether it is the desire, if I may so express myself, of obtaining as much light as possible on both surfaces of the leaf or perhaps rather a tendency to avoid the burning rays of the noonday sun by presenting to it the edge of the leaf, or both causes together, I leave undetermined. We at all events, owe our thanks to Major Alvord for having with a pertinacity which only a thorough conviction of the truth of the fact could have given him, forced the knowledge of a circumstance so interesting to physiological botany on the unwilling mind of naturalists.

low *Juglans nana,* a shrub, that bears nuts of the size of a musket ball. In place of the mulberry of your river bottoms, we find there the small *Morus parvifolia,* with leaves of one-fourth the size. The fine hackberry (*Celtis occidentalis*) one of the largest trees on the fertile lands of our western woods, is there represented by a spring shrub of a nearly allied genus, which not being able to find described in any work within my reach, I have assumed to name *Acanthoceltis.*

In place of the buckeye, from which the citizens of your state sometimes receive a cognomen, we find there the pretty dwarfish *Aesculus discolor,* which, however, also occurs in many southern States, and the nearly allied *Ungnadia,* peculiar to those regions and remarkable for its small, sweet, but intoxicating and emetic nuts.

The plum trees, not large in the north, become considerably smaller here; so *Prunus rivularis* and especially the very curious *Prunus minutiflora,* the leaves and flowers of which are hardly larger thau cranberry leaves. Even the small red-bud tree is there represented by a low shrub, the *Cercis occidentalis.*

All the shrubs just mentioned are representatives of northern trees; but one at least, the *Guajacum angustifolium* holds the place of a tree, the well known lignum vitæ.

A few ligneous plants, arborescent along the coast, become shrubby in the region of the calcareous plateaus. So the majestic live oak, the elegant evergreen *Sophora speciosa,* the valuable *Condalia obovata.* which the settlers use for dying blue.

Again, other plants, the relatives of which in the north are herbaceous, become there shrubby. Among these I will only mention several *Euphorbiaceæ,* and principally *Crotoneae,* some *Leguminosæ,* and more than all the *Mimoseæ.* This elegant tribe of plants, considered by some to be the highest type of vegetable development, has towards the north, hardly higher up than the latitude of the Missouri river, only a few straggling low herbaceous representatives; farther south the species become more numerous but all are herbaceous untill coming on the Gulf shore to the *Vachella,* and westward on the Canadian river to the shrubby *Algarobia glandulosa* and *Mimosa borealis.* Only after having crossed the Brazos, and still more the Colorado rivers, we meet with numerous shrubby *Mimoseæ,* some of them very elegant or very fragrant, and one, the well known Mezquite (commonly called Muskit) of southern Texas and northern Mexico, the same *Algarobia* which has just been mentioned, becomes a large tree, reversing therein the general character of the ligneous plants of that region, important because in some parts of the country it becomes the only firewood.

A large number of these shrubs have long-pointed or shorter-hooked spires; so the *Acanthoceltis,* almost all the *Mimoseæ,* and the *Condalia,* already mentioned; and with them a large number of *Rhamnaceæ,* some *Rosaceæ, Xanthoxylon, Castela*; the pretty *Berberis trifoliolata* has spiny evergreen leaves. Numerous *Yuccas,* with acutely pointed leaves, (called "Spanish Bayonet,") and the bromeliaceous *Dasylirions,* with sharply serrated leaves, together with the divers representatives of the *Cactus* tribe, complete this peculiar offensive, or rather defensive, character of that vegetation, which I am inclined to call the "*Chaparal-flora,*" from the Mexican name, indicating dense shrubbery, a name which has become familiar to us since the war.

The *Cactaceæ* have been alluded to above. They deserve some farther notice, as characteristic of that region. A few straggling representatives of this family are found farther north and east. The well-known "Prickly Pear," (*Opuntia vulgaris*) is the only species discovered in the old States; one or two other species of the same genus are found west of the Mississippi, and on the upper waters of the Missouri; and there, also, a few mammillariæ make their appearance. But only after crossing the Brazos river, and entering what I have called South-western Texas, you get into the proper region of the *Cactaceæ,* which, from there, extends, southwardly, almost through the whole continent. The northern forms, that inhabit the Rio Grande country, (and, also, those of New Mexico,) show some peculiarities which distinguish them, in some measure, from those farther south.

Several species of *Opuntia,* a genus which is more widely distributed over the continent than any other of the family, are found there; most of them of the usual well-known form, with flat joints; some prostrate on the ground; others erect, and often forming stems of six inches diameter (*Opuntia Lindheimeri*). Another singular tribe of *Opuntiæ,* with cylindrical joints, is there represented by a single slender shrubby species, (*Opuntia frutescens*) while to the west and south the splendid tree-like *Opuntia arborescens* borders along the confines of this region. Procumbent *Opuntiæ,* with short club-shaped joints, occurring with the last-named species, can hardly be said to belong to our district.

A number of *Mammillariæ,* several of them with large and beautiful flowers, are frequent there. A large cake-shaped *Echinocactus,* (*E. texensis*) is common all over that region, and a peculiar tribe of that genus, the most common of which is *E. setispinus,* characterized

by fleshy berries, (the fruits of the Echinocactus are generally dry,) covered with very thin membranaceous scales, appear to be characteristic of the flora of the Rio Grande valley. But the most beautiful Cactaceæ of that country are the low, as it were stunted, almost globose species of *Cereus*, (comprised under the sub-genus *Echinocereus*,) with delicate flowers, often larger than the plant itself. These forms extend into New Mexico, and into the northern provinces of Mexico, but appear to be unknown farther south, where the species of this family are most fully and most numerously developed. No other genera of this peculiarly American family have been discovered in Texas.

The south-western part of Texas will soon become better known to us, through the continued exertions of Mr. Lindheimer, and through the praiseworthy exertions of Mr. Chas. Wright, who is now for the second time on his way from San Antonio to El Paso, and of Dr. Bigelow, of your State, attached to the Boundary Survey, who has excellent facilities for exploring the region along the Rio Grande river.

Prof. MATHER called the attention of the Association to a geological chart, exhibited by him, and prepared by Prof. Jas. Hall.

FIFTH DAY, FRIDAY, MAY 9, 1851.

(Afternoon Session).

THE Association met at $3\frac{1}{2}$ P. M.

The PRESIDENT in the chair.

The minutes of the meeting of the Standing Committee were read, and action thereon deferred until the close of the afternoon meeting of the Association.

The following papers were then presented:

1. ON THE DISTRIBUTION OF THE CRINOIDEA IN THE WESTERN STATES. By Prof. L. P. YANDELL.

HAVING been engaged for several years past with my friend, Dr. B. F. Shumard, in collecting materials for a monograph on the crinoidea of the Western States, I propose to submit a few details respecting the distribution of the remains of this interesting class of animals through the palæozoic rocks, of this portion of the Mississippi valley. The richness of this quarter of our country in these fossils has already been made known to the scientific world by the labors of the late lamented Dr. Troost, whose monograph on the crinoidea of Tennessee is in course of publication under the auspices of the Smithsonian Institution. The list of the great naturalist of Tennessee includes about thirty genera and a hundred species, most of which, when he wrote, were undescribed.

The collection of Dr. Shumard and myself includes specimens from Ohio, Indiana, Illinois, Iowa, Missouri, Tennessee, Kentucky, and Alabama, extending from the lower silurian rocks to the beginning of the coal series, and amounts to about twice the number of species described by Dr. Troost. In the present state of our knowledge we would not ven-

ture to pronounce positively on the number, but we believe it will be found rather to exceed than fall short of thirty-five genera and two hundred species, of which a few are described by Prof. Hall, in the Palæontology of New York, some have been published by Drs. Owen and Shumard, in the Journal of the Academy of Natural Sciences of Philadelphia, and many are embraced in the forthcoming work of Dr. Troost, but a great part are new.

One of the first facts which arrested our attention in regard to our crinoids, is the limited geographical range of all but a few species. While we met with the same brachiopods and corals over wide aeas, we soon had occasion to remark that encrinites were limited to a few narrow localities. *Caryocrinus ornatus* is perhaps the most widely distributed of our species. It is found near Louisville, Ky., and in Decatur county, Tenn., as well as at Lockport, N. Y., where it was first discovered. One of Dr. Troost's new species is also widely diffused—the *Agaricocrinus tuberosus*—having been found at White's Creek Springs, near Nashville, Tenn., in the vicinity of Scottville, Ky., and at Warsaw, Ill., and the same is true of *Olivanites verneuilii*, Troost (formerly *Pentremites verneuilii*), which occurs abundantly in the upper strata of the Falls of the Ohio, and presents itself in the States of Ohio and Indiana wherever those strata are exposed. A few other species occur at various points, but much the greater number appear to have been restricted to a single spot.

With so circumscribed a range, it will not be thought singular that nearly all the species in our cabinets are peculiar to the Mississippi valley. I am aware how unsafe it is to decide hastily as to the identity or diversity of species bearing a close resemblance to each other, but after the first investigation I have had time to give the subject, my impression is, that not a single one yet found in the Western States is common to Europe and this country. Drs. Owen and Shumard incline to the belief that *Platycrinus granulatus*, and *Poteriocrinus plicatus* belong to our formations. It may be so, but if the European and American species are identical they form solitary exceptions amid a great multitude of forms. We have traced analogy everywhere, but examples of identity are still doubtful. The analogy between our species and those of Europe occurring in equivalent systems is, indeed, one of the most striking and interesting facts discovered in the progress of our researches. The *Cystidea* of Russia, Sweden, and England have their analogues in the Silurian rocks of Kentucky and Tennessee. Troost's *Echinocrinus fenestratus* answers to species of

Echino-encrinus which occur in Russia; and we have lately discovered in the neighborhood of Louisville, and in Decatur county, Tenn., specimens of what Prof. Hall pronounces a *Spheronites*, corresponding to the same form which has been found in the Silurian strata of England. *Caryocrinus*, which is peculiarly American, is represented by *Hemicosmites* at St. Petersburg. The *Agaricocrinus tuberosus* of Troost has a striking resemblance to *Actinocrinus amphora*, found in equivalent formations in Ireland. The genera *Platycrinus*, *Actinocrinus*, and *Eucalyptocrinus* occur in the rocks of our country which are equivalent to those affording them in Europe, and contain species which it is difficult to distinguish from their European analogues—so difficult, indeed, that several have been taken for the same.

We have had many opportunities to remark the exceedingly limited vertical range of our crinoidea, as other observers have done before, and are prepared to assert with great confidence, that not one of our species occurs in more than one formation. For the most part, each is contained in a thin and well-defined stratum, beyond the borders of which it is seldom to be traced. Not a single species is common to the lower and upper Silurian systems, or to the Silurian and Devonian, or to the Devonian and Carboniferous, much less to the three systems; and the same, with slight qualifications, might be said of genera, as will presently appear. No fossils, it is believed, will be found to be more characteristic of their containing strata, or to mark more precisely the limits of succeeding systems, than the crinoids.

We have met with crinoidal remains at a point lower in the geological scale than they were ever before disovered. Dr. Shumard first saw their broken columns in Wisconsin and Minnesota, several hundred feet below the magnesian limestone, in strata corresponding to the Potsdam sandstone of New York—showing that this curious race of beings were among the earliest tenants of the deep. They appeared with the primeval brachiopods and crustaceans, and have maintained their existence through every successive epoch, but in varying proportions, and in singularly diversified forms. In the oldest Palæozoic rocks we detect only, scattered here and there, the fragments of their stems and bodies. In the Trenton group of New York, and in its equivalent rocks in the West, we find a few genera and species, in a good state of preservation. In the Niagara group, at the middle of the Silurian system, we discover a sudden and great expansion of the race, which soon after seems to have begun to decline, and to have been less abundant throughout the Devonian era. But in the age which

followed, they attained a great development; the Carboniferous era was the age of the crinoids. Thus, in our collections, we have from the lower Silurian system 6 genera and 6 species; and from the upper beds of that system, chiefly the Niagara group, we have 10 genera and 40 species. From the Devonian rocks, we have 10 genera and 17 species; while from the Carboniferous system we have 12 genera and 150 species.

I do not suppose that these figures represent accurately the ratio of the species in the several systems, for our opportunities for collecting from all have not been equally good; but I feel assured that they will be found to be an approximation to the truth. At Louisville, the Devonian rocks are well displayed; but we have found them less rich in these fossils than the strata of an earlier age; and from one or two localities in the Carboniferous formations, we have obtained a greater number of species than this system has hitherto afforded. The fact seems to be a general one, that the crinoidea experienced a remarkable increase about the middle of the Silurian epoch—that they were stationary, if they did not decline, during the Devonian era, and reached their utmost expansion in the ages that succeeded. It has been remarked by Prof. Hall, as true of the formations of New York; and the same has been the experience of European geologists.

With the succession of formations, we have a remarkable shifting of genera, and change of form, and external ornament. *Glyptocrinus, Schizocrinus, Heterocrinus,* and *Agelacrinus* cease with the older Silurian strata, and are succeeded by *Haplocrinus, Eucalyptocrinus,* and by *Caryocrinus, Balanocrinus, Cupellœcrinus,* and many undetermined genera peculiar to our continent. These, in turn, are left behind when we ascend to the Devonian series, in which we find other forms and new genera. Here we meet with a crinoid with four bulky arms, destitute of a stem—a free-moving encrinite, showing, thus early, an approach in this family towards the starfishes, placed just above them in the animal scale. At this point, too, occurs our first *Actinocrinus,* which, like the forms abounding in the preceding series, is remarkable for the beauty of its external ornament. And here we also encounter a new crinoidal type—the *Pentremites*—already prefigured in *Eucalyptocrinus* of the middle Silurian period. Dr. Troost described as *Pentremites Reinwardtii,* a form which he was the first to discover in Decatur county, Tenn., and which, from its associated fossils, has been generally assigned to the Silurian age. Strictly speaking, *Pentremites Reinwardtii,* though bearing the closest analogy to that group, is not a

pentremite, but must be placed in a new genus along with some other organisms found in rocks of a similar age. From the fact that it is found in Tennessee accompanied by *Calceola*, a Devonian fossil, and that we also find it at the Falls of the Ohio, in strata unquestionably Devonian, I do not hesitate to refer it to this system. Along with it, at the latter locality, two or three species occur closely related to it, together with *Olivanites Verneuilii* Troost, and one or two species of the same genus.

Just above the beds containing these forms, the limestone series cease, and the black slate is superimposed. With the incoming of this formation, we lose all vestiges of the crinoids, until we reach an intercalated stratum of limestone near its summit, where encrinital remains again become abundant. This stratum of encrinital limestone is regarded as the base of the Carboniferous system, containing as it does among its imbedded fossils, *Orthis Michelini, O. crenistria, Terebratula Roissyi, Spirifer striatus, Productus punctatus, P. semireticulatus, Phillipsia, Griffithidis,* and encrinites of forms known only to that system in Europe.

The aspect of the crinoids of this period is eminently distinctive—in some respects denoting inferiority to the older forms, in others indicating advancement. The exquisitely ornamented surface has, for the most part, disappeared, and a plain exterior succeeded ; but with it we have tentaculated fingers, and a generally more complicated organization. In this age *Actinocrinus* attained its full development, and the species of *Cyathocrinus*, if they did not appear here for the first time, only became abundant at this period. *Platycrinus*, incorrectly placed in the older series, had its beginning with this formation, and was accompanied by *Dichocrinus* and *Synbathocrinus*, by Troost's *Conocrinus, Agaricocrinus, Catillocrinus*, and by many other new, undetermined genera. The graceful *Agassizocrinus* of Troost, a stemless, free-swimming form, like the asterias, was rife in this age, and had for its companions *Melonites* and the true *Pentremites*, which latter must have swarmed in the seas that gave origin to our mountain limestone. *Productus florealis* occurs near the base of this formation, and is found in all its divisions up to the topmost strata. With the pentremites, we find still another novel form, intermediate between them and the new genus *Melonites*—the *Granatocrinus cidariformis* of Troost; and here, too, we meet with *Cidaris* and other echinoderms.

This succession of genera is a striking feature in the history of the crinoidea, and their extinction at various periods, affords a problem of

great interest to the zoologist. Why they should, one after another, have perished from the early seas in which they lived, to be succeeded by other and still distinct forms, is a mystery which must, perhaps in most cases, remain forever unexplained; but in some instances a satisfactory solution seems to be attainable. Sir Charles Lyell, in his Manual of Elementary Geology, describes the "Bradford apiocrinites" as having grown in an oolitic limestone, upon which their stony roots now form a continuous pavement; a layer of clay rests upon it, containing the bodies and stems of innumerable encrinites. "In this case," he remarks, "it appears that the 'Great Oolite' had supported, for a time, a thick submarine forest of these beautiful zoophytes, until the clear and still water was invaded by a current charged with mud, which threw down the stone-lilies, and broke most of their stems short off near the point of their attachment." At several localities I have observed traces of a similar succession of events. The Buttonmould Knob, in the vicinity of Louisville, affords a striking example. A thin bed of limestone, deposited near the top of the Black Slate, is made up almost exclusively of the exuviæ of encrinites, showing that these animals abounded in clear water charged with carbonate of lime. The formation changes, and the crinoids disappear, having been entombed in the argillaceous deposit in which their remains are imbedded. In places where the clay is unmixed with iron, the fossils are in an excellent state of preservation; where iron mingles with it, they are generally fragmentary and imperfect.

We have satisfied ourselves of the carnivorous habits of the crinoidea. In one of our earliest excursions, we discovered a curious encrinite with an acroculia between its fingers, as if it had been in the act of devouring it when it perished. At Cincinnati we have been shown several specimens, in which a trochus is thus entangled in the rays of *Glyptocrinus decadactylus*, and we have lately received from our friend, Mr. Worthen, of Warsaw, Ill., a platycrinus, and more than one species of actinocrinus, with an acroculia in a similar position. The gasteropods seem to have been their favorite article of food.

The prevalence of the crinoids in this country, as compared with Europe, is a fact that will strike every observer. Dr. Troost supposed that he had collected together the remains of a greater number than were at that time known to European palæontologists, and the list known to him has been already more than doubled. These organisms are to our continent what the crustaceans are to Europe—the ocean-lilies swarmed along the shores of our early seas, as the trilobites did

in the ocean which has given place to the old world. Entering at the same time upon the stage of existence, at the earliest dawn of creation, the trilobites reached their meridian in the first Silurian epoch, and died out at the beginning of the coal period. The crinoids only attained their full development in the Carboniferous era, and extending through the Mesozoic period, have still their representatives among existing races.

2. On the Special Homologies of the true Starfishes and Crinoids. By Prof. L. Agassiz.

[*Not Received.*]

3. On a New Theory of Statements by Proportions. By Thos. Rainey, Esq.

[*Not Received.*]

4. On a Specimen of the Fossil Ox (Bos Bombifrons), found in Trumbull County, O. By Prof. Samuel St. John, of Hudson, O.

[*Not Received.*]

5. On the Number and Distribution of Fossil Species in the Palæozoic Rocks of Iowa, Wisconsin, and Minesota. By Drs. D. D. Owen, and B. F. Shumard.

So far as our investigations have been carried into the palaeontology of the formations of the North-west, embraced between the Carboniferous and oldest sandstones of the Silurian system, the total number of species amounts to 320, included in 102 genera.

They are distributed through the different periods as follows:

In the	Lower Silurian,	45	species,	included in	46	genera.
"	Upper "	36	"	"	26	"
"	Devonian,	49	"	"	26	"
"	Carboniferous,	120	"	"	49	"

Of the above genera, 32 are peculiar to the Silurian, 5 to the Devonian, and 36 to the Carboniferous. Of the 32 Silurian genera, 26 belong exclusively to the lower division, and the remainder to the upper division. 8 genera are common to the Silurian and Devonian, 10 to the Silurian and Carboniferous, 10 to the Devonian and Carboniferous, and 9 are common to the three systems.

The genera and species are distributed through the orders of the animal kingdom as follows:

In the Lower Silurian system—

11 species, included in 7 genera, belong to the Polyparia.
6 " " 5 " " " Acephala.
1 " " 1 genus, " " Pteropoda.
22 " " 9 genera, " " Gasteropoda.
40 " " 6 " " " Brachiopoda.
13 " " 5 " " " Cephalopoda.
2 " " 2 " " " Crinoidea.
20 " " 11 " " " Crustacea.

In the Upper Silurian system—

14 species, included in 12 genera, belong to the Polyparia.
1 " " 1 genus, " " Acephala.
4 " " 3 genera, " " Gasteropoda.
10 " " 5 " " " Brachiopoda.
6 " " 4 " " " Cephalopoda.
1 " " 1 genus, " " Crinoidea.

In the Devonian system—

12 species, included in 8 genera, belong to the Polyparia.
2 " " 2 " " " Acephala.
4 " " 3 " " " Gasteropoda.
23 " " 6 " " " Brachiopoda.
2 " " 2 " " " Cephalopoda.
4 " " 4 " " " Crinoidea.
2 " " 1 genus, " " Crustacea.

In the Carboniferous system—

13 species, included in 10 genera, belong to the Polyparia.
12 " " 10 " " " Acephala.
1 " " 1 genus, " " Pteropoda.
5 " " 4 genera, " " Gasteropoda.
31 " " 7 " " " Brachiopoda.
2 " " 2 " " " Cephalopoda.
52 " " 12 " " " Crinoidea.
3 " " 2 " " " Crustacea.
1 " " 1 genus, " " Foraminifera.

Of the 151 species found in the beds of the North-west, from the top of the upper magnesian limestone to the base of the lowest sandstone, 23 have been identified with forms occurring in the lower Silurian strata of Europe. The following characterize the inferior system of both countries:—*Leptæna sericea, Leptæna alternata, Orthis testudinaria, Spirifer biforatus, Lingula quadrata, Pentamerus oblongus, P. laevis, Porcellia ornata, Pleurotomaria lenticularis, Obolus appolinis, Isotelus gigas, Illaenus crassicauda, Ceraurus pleurexanthemus,* and *Chaetetes lycoperdon.* The remainder correspond with species of the Wenlock formation, several species, however, being common to it and the Devonian system. They are:—*Catenipora escharoides, Favosites gothlandica, Favosites spongites, Porites pyriformis, Terebratula reticularis, T. Wilsonii, Leptæna depressa, Spirifer trapezoidalis,* and *Pentamerus galeatus.*

As might be expected, a much larger number corresponds with species occurring in the equivalent beds of New York, Ohio, Kentucky, and Tennessee. At least 46 have proved to be identical with species ranging between the Potsdam sandstone and the Niagara limestone; 37 of which may be referred to species distributed through the Trenton limestone, Utica slate, and Hudson river group, as follows:—*Chaetetes lycoperdon, Conularia trentonense, Ambonychia undata, A. amygdalina, Nucula levata, Bellerophon bilobatus, Pleurotomaria lenticularis, P. subconica, P. umbilicata, Subulites elongata, Murchisonia subfusiformis, M. bellicincta, M. tricarinata, Cyrtoceras macrostomum, Orthoceras vertebrale, O. laqueatum, O. junceum, Leptæna planumbona, L. alternata, L. sericea, L. deltoidea, Terebratula hemiplicata, T. modesta, T. capax, Spirifer biforatus, Orthis testudinaria, O. tricenaria, Lingula quadrata, Echino-encrinites anatiformis, Heterocrinus heterodactylus, Calymene senaria, Isotelus gigas, Illaenus crassicauda, Ceraurus pleurexanthemus, Phacops callicephalus,* and *Lichas trentonensis.*

One species, *Gonioceras anceps,* is peculiar to the Black river limestone; one, the *Orthoceras multicameratum,* to the Birds's-eye limestone; and one, *Maclurea magna,* to the Chazy limestone.

Four appertain to the Clinton and Niagara groups:—*Pentamerus oblongus, Terebratula reticularis, Leptæna depressa, Catenipora escharoides.*

Among the 39 species from the Devonian rocks on the Upper Mississippi, between Parkhurst and New Buffalo, and at the other localities in the North-west, more than two-thirds are identical with species occurring in the shell and coralline beds of the Falls of the Ohio, in the vicinity of Louisville, and Charleston landing, Indiana.

The Onondaga limestone and Hamilton group of New York are represented by the following species :—*Leptæna depressa, L. inequistriata, T. reticularis, Terebratula concentrica, T. aspera, Spirifer macronotus, S. mucronatus, S. congesta, Pleurorhynchus trigonalis, Phacops crassimarginata, P. macrophthalma,* and *Favosites gothlandica.* This list will doubtless be greatly extended, when the forthcoming volumes on the palœontology of the higher rocks of the New York system appear, as they will afford means of comparison between the fossils of the two districts, not now at our disposal.

Thirteen species are identical with European forms, as follows :—*Lucina proavia, Spirifer heteroclytus, Terebratula reticularis, T. aspera, T. concentrica, Orthis resuspinata, O. umbraculum, Chonetes nana, Phacops macrophthalma, Astræa ananas, A. hexagonum, Stromatopora polymorpha, Favosites gothlandica,* and *Favosites polymorpha.* Of these, several belong exclusively to the Devonian strata in that country, while some extend downwards into the Silurian, and some above into the Carboniferous beds.

Of the 120 Carboniferous species collected chiefly in the State of Iowa, 24 are European species ; these are—*Chaetetes capillaris, Lithostrotium floriforme, Conularia quadrisulcata, Chonetes variolata, Orthis umbraculum, O. Michelini, O. resupinata, Terebratula plano-sulcata, T. lamelosa, T. Roissyii, T. sacculus, Productus punctatus, P. cora, P. Flemingii, P. costatus, P. semireticulatus, P. carbonarius, Spirifer striatus, S. cuspidatus, S. lineatus, S. rotundatus, Fusulina cylindrica, Platycrinus granulatus,* and *Poteriocrinus plicatus.*

It is remarkable, that, while more than one-half of the brachiopoda of this system can be referred to European species, only two out of the fifty-two crinoids have been recognized as common to the two countries.

From the foregoing, it appears, that the brachiopoda of these western palæozoic groups embrace the greatest variety of species ; the Silurian period furnishing the greatest number of this order ; the Carboniferous next ; while the Devonian rocks have as yet supplied the fewest. This is partly to be accounted for, however, from the limited area over which this latter group of rocks is accessible. The crinoidea rank next to the brachiopoda, in the abundance of species ; about nine-tenths of these are from beds of the Carboniferous age.

Next to the crinoidea, in numerical importance, come the crustacea ; this order being by far the most numerous in the Silurian period, which has furnished four-fifths of the whole number of species. The

Cephalopeda, which are next most abundant; the latter system affording the greatest amount of species. The same is also true of the Gasteropoda.

The Polyparia, on the other hand, appear to be most abundant in the Devonian rocks; indeed, some of these beds, in Iowa, are made up almost entirely of corals. The Acephala appear to be most abundant in the carboniferous rocks. Only two species of Pteropoda have as yet been found, one of which appears in the Silurian rocks, and one in the Carboniferous; which latter formation has afforded the only species of Foraminifera yet obtained.

If we may judge from the abundance of coralloid limestones in the Devonian period, and the purity of these calcareous beds, with little silicious and argillaceous intercalations, we are perhaps justified in concluding, that the ocean, during that epoch, was both shallow and clear, compared with what it was during the periods which preceded and succeeded it. It is also worthy of note that the coral formations of the Devonian period, in the valley of the Ohio, Mississippi, and Red Cedar rivers, are found at localities where the streams form rapids, or low falls; from which it appears probable, that the Polyparia have erected their structures on submarine ridges of the Devonian seas, formed by the principal anticlinal axes existing at that geological epoch.

6. On the Detection of Organic Miasm in the Air, by Prof. George C. Schaeffer, Danville, Ky.

Modern chemistry furnishes us with ample means for the investigation of this interesting subject, and it is a matter of surprise that so little has been done in a field promising such fine results.

That malaria is caused, not by peculiar states of the atmosphere, but by some complex organic compound *floating* in it, is now the opinion of most chemists who have investigated the subject. This view has, however, gathered strength from the doctrine of fermentation and contagion as carried out by Liebig.

It is not within the scope of this paper to discuss the theory of malaria. The history of the subject gives us every reason to believe that miasms are complex organic compounds, not existing in the gaseous form at all temperatures. The question is this; Can we

detect such substances in the air by appropriate re-agents, and obtain some idea of their nature.

We have the well known direct experiment of Boussingault, in which organic matter was detected by the blacking of sulphuric acid, as well as several proposed modes of examination by Prideaux and others, but no extended series of experiments has ever been made. My attention was first drawn to the subject by repeated attacks of intermittent fever upon myself and family, immediately after removing to a house, within a quarter of a mile of which, we had lived several years with impunity. The singularly local nature of the miasm was thus forced upon my attention, and from extensive observation I became convinced of the soundness of the theory above mentioned.

I then devised the following experiment, which was, however, not continued for a sufficient length of time: a quantity of good white sugar was partially converted into glucose by boiling with oxalic acid. Two equal portions of this solution were placed, one out of doors, the other within. I had expected that any organic miasm would excite fermentation in the one much sooner than it would take place spontaneously (?) in the other. The time of exposure—less than half an hour—and the limited surface of the fluid, were manifestly inadequate to the production of any decided results. But I mention the experiment, as I have reason to think that in the apparatus about to be described, it would be worthy of trial.

The subject was dropped upon my removal to a region not affording well marked miasmatic districts. But upon the return of the Asiatic cholera to this country in 1849, I was reminded by my friend, Dr. D. I. Ayres, of certain reputed cases of the blacking of sulphuric acid during the previous visit of this disease.

This led to the trial of a modification of Boussingault's experiment previously contrived. For convenience, a Deville's gasometer, in glass, was used as an aspirator, and the air was drawn through a ⊔ tube joined to it by an india rubber connection. The horizontal part of the tube was nearly filled with concentrated sulphuric acid, and when the aspirator was in action, this tube was slightly inclined, and the passage of the air regulated with great nicety. To increase the surfaces of air and acid in contact, bits of glass rod were introduced into the acid, and seemed to answer very well. An alteration in the aspirator, when used for such purposes, deserves to be mentioned. The syphon through which the water flows, should be in two pieces,

united by a flexible india rubber tube, and the lower end of the syphon tube curved upwards. By elevating or depressing this, the flow of the water may be regulated with great precision,

In these experiments, each minute bubble of air, remained, on an average, from five to six seconds in contact with the acid. It was soon found that the gasometer, of one gallon capacity, was too small, and as the disease prevailed to a trifling extent only, it became evident, that to obtain any result, the trial must be continued on a much larger scale. Two cans, of ten gallons capacity, were then used as aspirators, the water running from one to the other; the simple transfer of the cork stopper containing the tubes, fitting up either one to act as the aspirator. The apparatus thus made, worked with great regularity, and the experiments were continued night and day, for several weeks. The ten gallons of air were made to pass through the re-agent—generally less than half a cubic inch being used—in from twelve to twenty-four hours time, and the air was, consequently, completely washed in its passage.

In one experiment, forty gallons of air were passed through a small quantity of acid in the tube. In no case, however were the results decisive. The intention was to heat the tube in boiling water, and then compare the tint with a scale obtained by acting with sulphuric acid, on variously diluted solutions of some organic matter, such as sugar. I have since ascertained that the presence of a small quantity of nitric acid, seriously impaired the value of this test.

Nitrate of silver, in solution, gave more than once a fine black powder, but too small in quantity to be examined.

The following additional tests were devised, and one of them tried. They were all adopted on account of their change of color under the influence of organic matter. Solution of chromic acid, permanganate of potash, chloride of gold, and others of similar character.*

The suggestion of the same tests for the detection of minute quantities of organic matter in water, by Forchammer, and their employment in a colorimetric method almost identical, has encouraged me to adhere to the plan proposed.

The results of these experiments, are, it is true, almost negative; but it should be mentioned that the disease was exceedingly mild in the region in which they were tried. The chief value consists in the determination of the quantities of the air to be experimented upon.

* Millon's test for proteine compounds seems worthy of trial, as giving a clue to the composition of substances found in the air.

It would seem that at least forty gallons are required to produce an effect in the sulphuric acid, though if that re-agent be carefully deprived of nitric acid, smaller quantities may answer.

With nitrate of silver, a few gallons of air seem to produce an effect. Permanganate of potash will, probably, answer better than any other test. It could not be procured at the time of making these experiments. Forchammer prefers it, as a test, for organic matter in water. A careful microscopic examination of the contents of the tubes, must, of course, be made.

The experiments should be carried on under every variety of circumstances; and it is one of the objects of this notice to invite the laborers into the field—the larger the number the greater will be the value of the results.

The reading of the papers on the programme having been finished, the Association proceeded to the concluding business of the meeting.

In view of the importance of an early issue of the volume containing the Proceedings of the Cincinnati Meeting, the Permanent Secretary was directed to receive no communications for insertion, after the 20th of May.

The following resolutions were then passed by the Association:

Resolved, That the Standing Committee, in the name, and under our authority, have power to complete any unfinished business, after the adjournment of the meeting.

Resolved, That the members of the Association for the advancement of Science, will cordially unite in contributions towards a testimonial in memory of the great services rendered by the late Professor Schumacher, of Altona, to the cause of mathematical and physical science throughout the world.

Resolved, That the President of the Association be requested to take the necessary steps to communicate the intentions of the Association to the scientific bodies at home and abroad, who may be expected to unite in such a testimonial.

Resolved, That the following gentlemen be appointed a committee to memorialize the legislature of Ohio, on the subject of a geological survey of that State:

Judge LANE, of Sandusky, *Chairman;* JOHN ANDREWS and SAMUEL MEDARY, Columbus; Judge VANCE, Hamilton; JOHN H. JAMES, Urbana; Prof. SAML. H. ST. JOHN, Hudson, Summit county; ROBT. BUCHANAN, Esq., and JOHN P. FOOTE, Esq., Cincinnati; Hon. ALLEN TRIMBLE, Highland county; Hon. S. J. ANDREWS, Cleveland.

Resolved, That the following gentlemen be appointed a committee to memorialize the legislature of Missouri, on the subject of a geological survey of that State:

Prof. B. SILLIMAN, Sen., New Haven; Dr. S. G. MORTON, Philadelphia; Prof. A. D. BACHE, and Prof. JOS. HENRY, Washington; Prof. L. AGASSIZ, Cambridge; Dr. GEO. ENGELMANN, and Dr. H. KING, St. Louis; ROBT. BUCHANAN, Esq., Cincinnati; Prof. JAS. HALL, Albany; Major M. L. CLARK, St. Louis.

Resolved, That the committee on scientific explorations be requested to consider the propriety of memorializing Congress, on the subject of granting public lands for the purpose of carrying on a geological survey of the State of Missouri.

Resolved, That the committee for memorializing Congress in relation to scientific explorations, be requested to extend their duties to the memorializing Congress on such scientific objects as may be presented to them by the Standing Committee, provided that they approve of the same.

The Committee on collecting funds to publish the Proceedings of the Meeting, having reported that the citizens of Cincinnati had claimed the privilege of meeting this, as well as the other expenses, it was

Resolved, That the liberal contributions by the citizens of Cincinnati, to the objects of the American Association, by assuming the expense of publishing the Proceedings of the Meeting, in their city, as well as

all other expenses, entitle them to the warmest thanks of the Association, which are hereby tendered to them.

Resolved, That those gentlemen who have contributed five dollars and upwards, towards publishing the proceedings of the meeting, be furnished with a copy of the book.

The following changes were made in the committees:

The committee on memorializing Congress, in relation to attaching a corps of naturalists to the Mexican boundary survey, was discharged, after reporting that the object of the commission had been accomplished.

The committee on memorializing the Legislature of Pennsylvania, relative to the publication of the final geological report of the State, was likewise discharged, and for a similar reason.

Dr. YANDELL and Prof. O. M. MITCHEL, were added to the Committee on the United States Coast Survey.

SEARS C. WALKER, Esq., Capt. CHAS. WILKES, and Prof. J. H. C. COFFIN, were added to the Committee on Prof. MITCHEL'S New Astronomical Methods.

The remaining committees were all continued.

The following votes of thanks were then presented, and unanimously adopted:

Resolved, That the thanks of this Association be returned to the Trustees of the Cincinnati College, to the Trustees of the Mechanics' Institute, to the members of the Western Academy of Natural Sciences, of the Young Men's Lyceum of Natural History, the Directors of the Cincinnati Observatory, and of the Young Mens' Mercantile Library Association, for the very liberal manner in which they have opened their halls, meeting-rooms and collections, to the use of the Association.

Here Prof. HENRY, of Washington, rose and begged leave to second that motion with all his heart. It was due as an expression of the feelings of the meeting, and not a mere form of words. He, and others, had come for the first time across the Alleghanies, and entered the broad valley of the Mississippi and Ohio. They were surprised and delighted! He had heard much of the Great West, much of the Queen City, and had come to put his anticipations to the test. He expected to see a boundless, magnificent forest world, with the scattered clearings and log cabin villages, and energetic New England-descended

inhabitants, he thought to find Cincinnati a thriving frontier town, exhibiting views of neat frame houses with white fronts, "green doors and brass knockers;" but, instead of this, he found himself in a city of *palaces*, reared as if by magic, and rivaling in appearance any city in the eastern states, or of Europe. But it was not things of mere stone, brick, and mortar which pleased him most in the queen of the west. Imperial Rome had her palaces and noble structures, but in her proudest days, she boasted not of a Mechanics' Institute, an Academy of Natural Sciences, a Mercantile Library Association, or of a Young Men's Lyceum of Natural History. *These* are the pride of Cincinnati—*these* her noblest works. Grateful as we ought to be, and are, for the kindness and courtesy shown us as members of the American Association for the Advancement of Science, we are more thankful to the Cincinnatians for having founded her Literary and Scientific Associations, and for liberally opening her treasuries of knowledge to the world.

Resolved, That the thanks of the Association be presented to those gentlemen of Cincinnati, of the State of Ohio, and of the West generally, who have laid before the members and submitted to the examination of their committees, the valuable collections of fossils which they have made, and which have been pronounced of the highest importance, not only to the development of North American Palæontology, but also to the advance of our knowledge of the history of the organic world.

Prof. Agassiz rose to second the motion. He was most rejoiced that he could heartily concur with the remarks of his friend, Prof. Henry, with regard to the pleasure which it gave him to witness these most sterling evidences of the spirit of Cincinnatians. He had particularly, and with the utmost satisfaction, examined the several collections of rare and valuable fossils exhibited before the Association. Though familiar with such exhibitions on similar occasions, both in America and in Europe, he could most safely say he had never known a more choice and valuable collection to be presented on any occasion. It spoke loudly for the interest taken in the progress of science in the Great West. The West offers a peculiarly interesting field, and our thanks were most justly due to those who had so industriously and carefully improved the advantages which nature had so generously offered, and thus added these valuable collections to the stores of science. This, he said, not only as an expression of his individual

gratification, but because he felt it his duty in the name of the Association, to give their decided opinion of the value and importance of these collections.

Resolved, That the members of the American Association return thanks to the citizens of Cincinnati, for the kind hospitality extended to them privately and publicly during the meeting in their beautiful city, taking it as an evidence of their interest in the progress of Science in the United States.

The adoption of this resolution was moved by Mr. FOSTER, United States Geologist, who remarked as follows:

In rising to move the adoption of the resolution, I wish to offer a single remark. There is, perhaps, no city in the United States, which affords so striking an example of the skill and energy of our people as Cincinnati. A half century has hardly elapsed since this region, now covered with massive structures, such as churches, warehouses, and shops, was an unbroken wilderness. My friend, Prof. Henry, has remarked, that this is his first visit to the West, and has expressed his admiration of its resources and capabilities. He has only reached the margin of the great valley between the Alleghanies and the Rocky Mountains. I hope he may be induced to visit the city of my friend on the right, (Dr. Engelmann, of St. Louis.) I hope he may extend his observations as far north as Detroit, and as far south as New Orleans. Even then he will be incapable of forming a correct estimate of the extent and resources of this great valley. Every where he will see the same evidences of prosperity which he has observed here. Aye, let him surmount the rocky barrier which divides the great valley from the Pacific slope, and even there he will behold abundant traces of the same stream of civilization, which has swept from the east into the valley of the Mississippi river.

Prof. SCHAEFFER, of Danville, Ky., requested to add his hearty second to this resolution. Having been, perhaps, first upon the ground, he had enjoyed the hospitality of the warm-hearted Cincinnatians longer even than others. They had received us not as guests, to whom courtesy required a polite attention, but as *friends,* when we have come as strangers; they have welcomed us, not only with open houses, but open hands and open hearts. They have made us feel at home. The members of this Association, however numerous and varied be their places of meeting, will never forget the cordial, warm

and heartfelt hospitality shown them by the citizens of the Queen City of the West.

Resolved, That the thanks of the Association be presented to the Directors and officers of the several Railroad Companies and Steamboats, who have so kindly offered, by a reduction of the fare, facilities to the members in coming to and returning from Cincinnati.

Resolved, That the thanks of the Association be presented to Messrs. Sellers & Whetstone, for the invitation to visit their Orograph, tendered by them to the Association.

Resolved, That the thanks of the Association be presented to the members of the Local Committee, for the zeal and efficiency with which they have performed the duties of their office.

Resolved, That the thanks of the Association be presented to the President, for the faithfulness and dignity with which he has presided over the present meeting.

To this the President replied:

I congratulate the members of the Association on the success of this, their first meeting west of the mountains. A general attendance of the cultivators of science from the West was to have been expected; but it was not supposed, even by the most sanguine, that so many of the laborers in the same field on the Atlantic slope, would, in spite of the great distances separating them from the Queen City of the West, assemble at the call of the Association. In this we feel the effects of the great facilities for personal communication which our times present, and which bring the citizens of Boston and Cincinnati nearer to each other now, than those of New York and Philadelphia were before the introduction of steamboats and locomotive engines. Let us acknowledge our debt to the men of the past and of the present day, to whom we owe this obligation, rivaled only by that due to those whose discoveries in science and persevering attempts to reduce them to practice, have afforded a means of written communication which may practically be called instantaneous.

The number of members in attendance has been about eighty-seven, and eighty-seven papers have been read, nearly equally distributed between the divisions of mathematical and physical science, geology and mineralogy, and zoology, botany and kindred branches. The im-

portance of the geological papers which have been presented can not well be overrated, and indicates an activity in collecting and comparing results, which must, in the end, produce the most useful fruit. The gradual progress of the knowledge now acquiring, will no doubt render induction from the facts more sure, and reduce to theoretical principles what now seem rather to be ingenious hypotheses. It is hardly possible that the intercourse between the cultivators of different branches of science, the friendly communion, the candid and temperate discussion, shall not react favorably upon the members themselves, and through them upon the progress of the various subjects to which they have devoted their energies. If we have made any mistake in our proceedings at this meeting, it has been in undertaking too much; in devoting so many hours to formal meetings, that informal intercourse has been almost impracticable.

The report on Prof. Mitchel's admirable astronomical invention, and the bringing to light the collections of numerous and highly interesting fossils, which have been pronounced by the highest authority to be unrivaled in their importance by any collections which the meetings of other Associations in America or Europe have produced, will mark this meeting in the annals of the Association. The success which has attended our former recommendations to State Legislatures in regard to Geological Surveys, and to the General Government in regard to the organization for the Mexican Boundary Survey, is indicative of the service which may be rendered by well considered recommendations on subjects which are the peculiar province of the Association.

The liberal action of the Societies of Cincinnati, having for their object the cultivation of science, and the furnishing their members with various means of instruction, in opening their rooms to the Association has contributed not a little to the gratification which we have derived from our stay in the city. The facilities furnished by the Railroad Companies, in the reduction of their fares, have been a great convenience to many. What shall I say of the admiration with which we have seen the growth and strength of this young Brobdignag, Cincinnati? to exhibit it, as is our custom, by a diagram, let us show Cincinnati in 1788,—a log cabin—and Cincinnati in 1851. What shall I say of the arrangements by the citizens, by which we have been, each one of us, while many hundreds of miles from our homes made emphatically "*at home?*" This kindness is to be felt, not spoken.

The President then adjourned the Association to meet at Albany, on the third Monday of August next.

SIXTH DAY, SATURDAY, MAY 10, 1851.

MEETING OF THE STANDING COMMITTEE.

In pursuance of a vote of the Association, the Standing Committee met at 8 A. M., to complete certain unfinished business. It was

Resolved, That the Committee on Weights and Measures be requested to report at the Albany meeting, all the facts which may be within their reach; and that notice be given in the circular of invitation, that the subject will be discussed on a specified day during the coming session of the Association.

Resolved, That copies of the Proceedings of the American Association for the Advancement of Science, be presented to the American Academy of Arts and Sciences, Cambridge; to the Boston Academy of Natural History; to the New York Lyceum of Natural History; to the American Philosophical Society, and to the Academy of Natural Sciences, of Philadelphia; to the Smithsonian Institution; and to the Western Academy of Natural Sciences, of Cincinnati.

Resolved, That in future no paper shall be entered on the programme for reading unless an abstract be previously furnished to the General Secretary, or the paper itself presented.

INDEX.

A

D

E

F

G

H

M

N

O

P

Q

R

S

T

U

V

W

Y

DATE.	5461 5507	5596 5620	5658 5708	5765 5937	6094 6129	6091 6482	6091 6528	6246 6482	6246 6528	6428 6642	6428 6647	6476 6642	6476 6647	6724 6741	6761 6814
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" 28		45,66		42.85											
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" 3	45.14					44.49	44.46								
" 4	44.54			43.20											
" 6	43.49	45,52													
" 7	46.69			41.96											
" 11			41.18	46.06				44.80	46.33					39.64	
" 13								43.01	43.17					44.12	
" 14				42.41		45.58	45.14							41.38	
" 17				42.47		43.91	41.82								41.32
" 18				45.08		42.35	42.94							38.68	
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DATE.	6867 6893	6959 7107	6959 7121	6959 7160	7193 7318	7418 7455	7547 7595	7651 7689	7759 7788	7827 7875	7908 7961	7997 8058	8056 8147	8058 8147	8268 8315	MEAN OF EACH NIGHT'S OBSER'S.	
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" 11	46.61	47.20	46.85	47.21	46.48	41.98	40.85	43.07	40.50		40.52					43.95	
" 13	41.72	44.56	45.36				38.89	45.02	39.00	42.58	40.81			41.94	43.84	42.52	
" 14	42.62	45.01	46.00	46.24												44.30	
" 17	47.36	42.78	41.83	43.63		43.76		44.17	39.07	42.16	38.52					42.52	
" 18	44.27	44.87	45.91	46.37		41.70		46.83	40.66	46.70		41.85		44.12	43.84	43.74	
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* Rejected.

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" 23	44.63	39,27	39.65			40.34	41.56	39,45	37.60	44.07		45.05		
" 24	46,96	44.43	45.00	42,24	46.21				41.17	49,69	47.72	48.59	46.62	36.17
" 25	46,22	45.05	48,66			43.13	44.34	42.65	41.71	44.72	43.51	44.45	43.26	
Sept. 4		44.63	44.00			43.08	42.59	41.12	42.83			44.93	41.46	38.78
" 5		47.68	41,45					39.00	37.72					
Means of each pair,	46.12	44.02	43.94	43,52	45.73	42.18	42.83	40.35	40.33	45.78	45.62	45.77	43.78	*36.93

DATE.	7193 7324	7421 7476	7567 7598	7605 7522	7605 7547	7629 7696	7629 7698	7659 7696	7659 7698	7815 7912	7971 8024	7971 8083	8125 8227	8268 8315	MEAN OF EACH NIGHT'S OBSER'S.	
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" 22				41.10	44.87		36.42		43.23	46.33	39.92	42,00	42.15		42.30	
" 23							39.40		46.76	44.43	40.41	37.90	43.39		41.59	
" 24	38.60	46.34	49.14			40.76	40.40	47.93	47.57	49.93	43.21	42.68	44.73	44.48	44.79	
" 25															44.34	
Sept. 4	40.94	42.06	42.83				37.13		45.00	45.80	40.43	39.24	43.08	43.77	42.31	
" 5															41.46	
Means of each pair,	39.77	44.20	45.99	41.10	44.87	40.76	38.34	47.93	45.64	46.62	40.99	40.46	43.34	43.98	32 35 43.26 32 35 43.48	Mean of each night. Mean of each pair.
															32 35 43.48	Mean of observ'ns.

* Disregarded in Mean.

Latitude obtained by giving to each pair a weight depending on the number of observations, 32 35 43.54 Most probable.

There are 190 results obtained from observations on eighty-two different stars. General mean of each night, 43″.73

" " of each pair, 43″.56

" " of all the observations, 43″.53

Probable error in determinations of the latitude from a single pair, 1″.48

Limit of probable error in determining the latitude from all the pairs, 0″.198